PROCEEDINGS

of the

American Gas Institute

SIXTH ANNUAL MEETING

OCTOBER 18, 19, 20, 1911

ST. LOUIS, MO.

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1912

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JAMES W. DUNBAR 1906-1908
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(*The authors only are responsible for their respective articles*)

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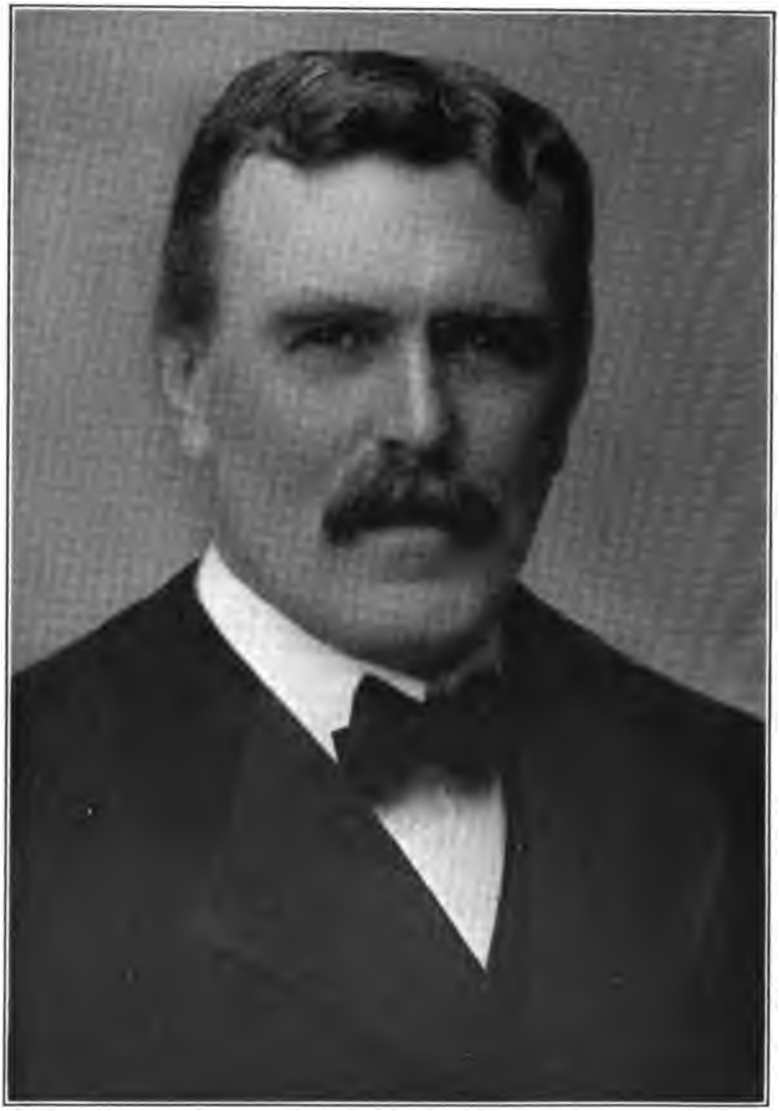


PRESIDENT

Report of the Proceedings

of the

American Gas Institute

Sixth Annual Meeting

held at

St. Louis, Missouri

October 18th, 19th and 20th, 1911

The Sixth Annual Meeting of the American Gas Institute was held in St. Louis, Missouri, in the Hall of the Art Museum, and opened its First Session on Wednesday morning, October 18, 1911, and was called to order at 10:10 by the President, Mr. Donald McDonald, of Louisville, Kentucky, Mr. A. B. Beadle, the Secretary, also being present.

THE PRESIDENT: Gentlemen, it is my pleasure to call to order the Sixth Annual Meeting of the American Gas Institute. The Mayor of St. Louis, the Honorable Frederick H. Kreismann, has been kind enough to come here to present us with the keys of the city. I don't want him to talk to a disorderly house. I am therefore going to ask all the members to find seats. Mr. Kreismann.

MAYOR KREISMANN: Mr. President and Gentlemen of the American Gas Institute, if the weather this morning has anything cheering in its sunlight, it is indicative of the pleasure that the people of St. Louis feel and the honor they recognize in your assembling in our city to hold your deliberations. Of the hearty welcome and the arrangements made

for your entertainment, I am quite sure, under the guidance of our fellow-citizen and your associate, Mr. Holman, you will be quite pleased, as it was a great pleasure to him I am sure to be a factor in bringing you here.

The industry which you gentlemen represent is one which has kept pace with its rival electricity, and which through invention, research and study on your part and a broad technical training of the men engaged in the gas business, has made it a utility not only as an illuminant but as the most modern and economical fuel product, especially for a large community. The invention of the product of that master mind Welsbach has enabled you to hold its illumination properties in keeping with the demands made upon electricity. The gas industry is one of the public utilities that is in itself a monopoly product. The very nature of the business, running largely into the commercial side, makes it necessarily a monopoly utility, if the greatest results in economy and the lessening of cost to consumers is the prime object. The fallacy of competition in this business has been well worked out in the minds of the people, and it has been the wise and prudent regulation of your business and the very careful and diplomatic conduct of your relation to municipalities and to the public that has made this principle better understood.

A cheap, ample and dependable supply of illuminant is one of the greatest civilizing factors in urban life. The police authorities sometimes say that every street lamp is a good constable. Nothing adds to the peace and order of a community more than proper illumination. The modern inventions and perfection of electricity, your great competitor, has caused you men to look to another field and another form of consumption, and that has run into domestic use for fuel. A wise forethought on your part has caused you to call into your business activities the distribution and sale and the encouragement of the use of your product by the installation of all kinds of modern appliances. That has brought convenience and comfort to every household and particularly to the households of the mid-

dle class. You have therefore many factors, and every home feels some betterment because of your activity.

In speaking of the gas business I hope I may not burden you with something that my mind was drawn to last evening, because I realized that I ought to give some attention, some little thought to what I might say to you here to-day in recognition of the dignity and importance of your business. I find that Europe, particularly Germany, England and Scotland, are serving the public by municipal corporations or municipal plants. America has not taken to that idea, and I think wisely so. It has allowed that industry and that utility to be served and furnished by private corporations, and in late years there has been a working to a much better understanding between the public and these private corporations, whereby the capital invested in your plants is to be better safeguarded and the product disposed of at a reasonable cost to the consumer and a fair profit to the capital invested. The City of Paris I understand is still served by a private corporation. Up to the year 1850 Paris was served by some seven or eight individual or separate plants each having its district, each being under the control or supervision of the authorities. In 1855 six of these plants were consolidated, resulting in better service, a more economical administration of the several plants and lessening of the cost to the consumer. In 1861 all of the plants were merged into one large unit of service. And what has been the result of that? This authority states that the city as a consumer in the lighting of its streets and public buildings is still using gas as an illuminant, is served at approximately the cost of production, and to-day the revenue to the City of Paris, as a consideration for the street rentals and the privileges of serving the public, is over twenty million francs a year. These are the ends that I believe will be reached in our large American cities, and I trust your deliberations and the influence of this Institute may push that end effectively.

Mr. President, it has always been customary as you antici-

pated, that you would receive to-day the keys of the city. It has been my pleasure to extend and to offer the keys of the city to many distinguished associations and business organizations that do us the honor to assemble in St. Louis, and it is a custom that is dealt in largely from a figurative standpoint, but in evidence of the fact that we have keys here and keys which fit all locks, I have taken the opportunity to present a real key to you. (Presenting a large key to the president.) I am glad that you are with us, gentlemen. (Applause.)

THE PRESIDENT: Gentlemen, I feel certain that the Institute wants to congratulate the City of St. Louis on having such a level headed Mayor, one who feels so kindly to the gas companies and one who knows so much about gas, and I will call on Mr. E. G. Pratt to speak for the Institute.

MR. PRATT: Mr. President, Mr. Mayor and Gentlemen: I have just entered the room and to be called upon, thus suddenly, to respond to such an enthusiastic welcome as has been extended to us, is something that is a little beyond me and yet, knowing the circumstances, I shall not shrink from the performance of a duty which, with the opportunity of making some preparation, would have given me great pleasure.

I know I can say for the gentlemen here assembled that we appreciate, Mr. Mayor, your presence here this morning. We appreciate your words of welcome and also the spirit which prompts their delivery. We accept the key to the city, but in so far as the necessity of its use is concerned, I think we all agree that, from past experience, no key is necessary as the gates of this hospitable City of St. Louis have, upon former occasions, been found open to us.

Referring to matters concerning the meeting of this Institute and what it means to its members, our consumers and city officials sometimes imagine that we gather at intervals of once a year or oftener to devise ways and means of reducing the quality of our product and increasing its price, but I should like to have the Mayor of this city understand, if it is not al-

ready understood by him, and judging by his intelligent and courteous remarks, he does understand, that we come here chiefly for the purpose of discussing those things which are to benefit, not only our customers, but ourselves as well. What benefits us benefits also the community which we serve and members of this Institute lay aside for a few days their duties at this time, for the purpose and for this purpose only; and if we could only impress upon the communities served and our consumers the thought that every effort is intended for their benefit and for their good and to make it so understood I believe the corporations to which the Mayor has referred, would be looked upon in an entirely different aspect.

It is not my purpose or intention to do more than to thank the Mayor on your behalf, for coming here this morning. As I have already said, we appreciate it. We know what the hospitality of the City of St. Louis is, as we have experienced it many times before this and while we shall make the most of it, I think I can safely say for these gentlemen, we will not abuse it. I thank you.

Minutes of Last Meeting.

The President: The reading of the minutes of the last meeting are in order. I would entertain a motion to dispense with them. Do I hear such a motion?

The motion was duly carried that the minutes of the last meeting be approved as written, without reading.

Welcoming of New Members.

The President: Next on the official program is the welcoming of new members. I want all the new members to know that they are welcome. I want them to feel free to take every opportunity that offers to take part in our proceedings. We are glad to have them. I will not put them through the awkward squad exercise of rising to their feet to be looked at, but I want them to know that whatever they have to say we shall be glad to hear, and if they belong to this body without the membership knowing that they are in it, it will be entirely

their own fault, because we shall always be glad to hear from them.

MEMBERS PRESENT.

The following gentlemen were present as registered:

ACTIVE.

Abell, H. C., New York, N. Y.
Africa, W. G., Manchester, N. H.
Alden, J. D., Waterbury, Conn.
Aldrich, W. A., Grand Rapids, Mich.
Allen, W. H., Jr., So. Chicago, Ill.
Alrich, H. W., New York, N. Y.
Andrews, C. W., Duluth, Minn.
Baehr, W. A., Chicago, Ill.
Bains, G. B., 3d., Ardmore, Penn.
Barlow, T. S., New York, N. Y.
Barrows, G. S., Philadelphia, Pa.
Barthold, W. H., New York, N. Y.
Batten, J. W., Detroit, Mich.
Battin, H. S., Philadelphia, Pa.
Bayly, C. C., Washington, D. C.
Beadenkopf, Geo., Baltimore, Md.
Beadle, A. B., New York, N. Y.
Bennett, C. W., Binghamton, N.Y.
Bertke, W. J., Sioux City, Ia.
Bill, B. P., Springfield, Mass.
Bixby, W. A., Springfield, Mo.
Blauvelt, W. H., Syracuse, N. Y.
Blauvelt, W. S., Detroit, Mich.
Bond, C. O., Philadelphia, Pa.
Boone, Charles, Brooklyn, N. Y.
Booth, Arthur, Pittsburg, Pa.
Brown, J. A., Detroit, Mich.
Brown, R. B., Milwaukee, Wis.
Bruce, Howard, Baltimore, Md.
Brundrett, E. L., Kansas City, Mo.
Buck, H. M., Waukesha, Wis.
Buckminster, Rollin, Lowell, Mass.
Burden, W. W., Long Island, N.Y.
Burgess, C. F., Madison, Wis.
Burkhart, H. W., Los Angeles, Cal.
Burt, Austin, Waterloo, Ia.
Butterworth, C. W., Milton, Pa.
Cabell, J. L., Savannah, Ga.
Castor, W. A., Philadelphia, Pa.
Cheney, Herbert N., Boston, Mass.
Chubb, C. N., Michigan City, Ind.
Clark, H. H., Oak Park, Ill.
Clark, J. C. D., Chicago, Ill.
Clark, W. J., Mount Vernon, N. Y.
Clary, E. D., Burlington, Ia.
Cline, W. B., Los Angeles, Cal.
Collins, Carroll, Marshall, Mich.
Collins, D. J., Philadelphia, Pa.
Combs, R. B., Philadelphia, Pa.
Cook, H. R., Jr., Philadelphia, Pa.
Cooper, W. H., Amsterdam, N. Y.
Copley, I. C., Aurora, Ill.
Cornish, R. C., Philadelphia, Pa.
Covert, I. C., Paducah, Ky.
Cressler, A. D., Wayne, Ind.
Curtis, S. P., Philadelphia, Pa.
Daly, A. J., St. Louis, Mo.
DeCastro, J. L., New York, N. Y.
Dell, John, St. Louis, Mo.
Dewey, V. F., Grand Rapids, Mich.
Dickey, S. J., Philadelphia, Pa.
Dodd, W. S., St. Louis, Mo.
Doherty, H. L., New York, N. Y.
Dorner, W. F., Philadelphia, Pa.
Douglas, H. W., Ann Arbor, Mich.
Dunbar, J. W., New Albany, Ind.
Dunn, F. S., Albany, N. Y.
Dutton, L. R, Wyncote, Pa.
Dutton, R. H., Hanover, Pa.
Eaton, A. B., Chicago, Ill.
Eaton, J. B., Rochester, N. Y.
Einstein, A. C., St. Louis, Mo.
Elbert, V. L., St. Paul, Minn.
Ellis, J. W., Providence, R. I.
English, A. L., Council Bluffs, Ia.
Evans, G. B., St. Louis, Mo.
Evans, O. B., Philadelphia, Pa.
Ferguson, B. B., Portsmouth, Va.
Fisher, D. G., Peoria, Ill.

Fisher, Howell, Everett, Mass.
Fogg, O. H., New York, N. Y.
Forstall, A. E., New York, N. Y.
Forstall, Walton, Philadelphia, Pa.
Fox, C. S., Long Island City, N. Y.
Freeman, F. C., Cincinnati, O.
Frick, J. A., Allentown, Pa.
Fulweiler, W. H., Philadelphia, Pa.
Furlong, W. G., Albany, N. Y.
Gadsden, P. H., Charleston, S. C.
Ganser, H. H., Norristown, Pa.
Gartley, W. H., Philadelphia, Pa.
Glass, S. J., Milwaukee, Wis.
Goodnow, G. F., Waukegan, Ill.
Gould, J. A., Boston, Mass.
Graf, C. H., Indianapolis, Ind.
Graham, A. S., Hammond, Ind.
Griffin, J. F., Oskaloosa, Ia.
Griswold, R. G., Denver, Colo.
Haftenkamp, J. P., Rochester, N.Y.
Hall, A. H., New York, N. Y.
Hardick, C. F., Philadelphia, Pa.
Harrington, A. S., Chicago, Ill.
Harrington, W. K., New York, N.Y.
Hartman, W. E., Joliet, Ill.
Hellen, Frank, Rochester, N. Y.
Hellen, John, Grand Rapids, Mich.
Hewitt, Arthur, Toronto, Ont., Can.
Hillemeyer, J. E., St. Louis, Mo.
Hodges, C. H., New York, N. Y.
Hoffman, Howard, Syracuse, N. Y.
Holden, T. F., Washington, D. C.
Holman, C. L., St. Louis, Mo.
Hone, F. deP., New York, N. Y.
Huber, Frank, Louisville, Ky.
Humphreys, A.C., New York, N.Y.
Hunter, C. W., Ocala, Fla.
Hunter, C. W., Boston, Mass.

Jacobson, E., Oak Park, Ill.
Jackson, T. H., Philadelphia, Pa.

Keene, A. M., Mt. Vernon, N. Y.
Kellogg, R. M., Mt. Vernon, N. Y.
Kennedy, J. P., Cambridge, Mass.
Keppelman, J. H., Reading, Pa.
Kingsbury, I. C., New York, N. Y.
Klumpp, John B., Philadelphia, Pa.
Lambert, E. L., Ironwood, Mich.
Lamson, W. O., Jr., W. Chester, Pa.
Lathrop, A. P., New York, N. Y.
Lea, H. I., Chicago, Ill.
Leonard, C. F., New York, N. Y.
Lewis, R. C., Brooklyn, N. Y.
Linton, S. E., Jr., Sioux Falls, S.D.
Littlehales, T., New York, N. Y.
Lynn, J. T., Detroit, Mich.
Lyons, J. F., Beloit, Wis.

McDonald, Donald, Louisville, Ky.
McDonald, D., New York, N. Y.
McDonald, Wm., Albany, N. Y.
McIlhenny, J. S., Washington, D.C.
McIlhenny, J. D., Philadelphia, Pa.
McKay, Wm. E., Boston, Mass.
McKenzie, W. H. Kansas City, Kan.
McLean, H. B., New York, N. Y.
Macbeth, A. B. Independence, Kan.
Macbeth, G. T., Mt. Vernon, N. Y.
Macklin, A. F., New York, N. Y.
McIntosh, W. L., New York, N. Y.
Malone, M. E., Denver, Colo.
Mann, H. E., Montreal, Canada.
Marrow, G. P., New York, N. Y.
Mayer, J. E. J., Chicago, Ill.
Miller, A. S., New York, N. Y.
Miller, Carroll, Providence, R. I.
Miller, R. W., Durham, N. C.
Miller, T. D., St. Louis, Mo.
Mockett, W. E., Scranton, Pa.
Morehead, J. M., Chicago, Ill.
Morrell, E. E., Chicago, Ill.
Morris, W. C., New York, N. Y.
Morrison, H. K., Brockton, Mass.
Morton, F. N., Philadelphia, Pa.

Nettleton, C. H., Derby, Conn.
Norris, Rollin, Philadelphia, Pa.
North, Edwin, New York, N. Y.
Norton, W. F., Nashua, N. H.
Nute, J. E., Fall River, Mass.

Offutt, M. W., Schenectady, N. Y.
Olds, H. L., Indianapolis, Ind.

Palmer, H. C., Buffalo, N. Y.

Papst, H. M., Portland, Ore.
Parker, J. S., Philadelphia, Pa.
Partridge, Warren, Springfield, Ill.
Pearson, W. H., Jr., Ontario, Can.
Perry, J. A., Omaha, Neb.
Philbrick, J. E., York, Pa.,
Polk, R. W., St. Louis, Mo.
Pratt, E. G., Chicago, Ill.
Printz, C. H., Cincinnati, O.
Quackenbush, C.H., E.St. Louis, Ill.
Quinn, A. K., Newport, R. I.
Ramsay, D. G., Chicago, Ill.
Ramsdell, G. G., New York, N. Y.
Ray, W. D., Hammond, Ind.
Reed, J. H., Jr., Pittsburg, Pa.
Reinhard, S. A., Chicago, Ill.
Rice, H. L., Aurora, Ill.
Roberts, F. M., Fall River, Mass.
Roberts, G. W., Bridgeport, Conn.
Roper, G. D., Rockford, Ill.
Ruegenberg, J. M., Phila., Pa.
Russell, D. R., St. Louis, Mo.
Russell, Herman, Rochester, N. Y.
Rutter, T. V., New York, N. Y.
Searle, R. M., Rochester, N. Y.
Shaeffer, J. W., Milwaukee, Wis.
Silverthorn, J. C. Evansville, Ind.
Simpson, C. C., New York, N. Y.
Simpson, C. C., Jr., New York, N.Y.
Slade, R. E., New Orleans, La.
Smith, E. W., Kewanee, Ill.
Snyder, A. I., Grand Rapids, Mich.
Snyder, C. S., Philadelphia, Pa.
Steinwedell, Carl, Quincy, Ill.
Steinwedell, W. E., Cleveland, O.
Stiles, L. S., Brooklyn, N. Y.
St. John, John, Madison, Wis.
Strain, G. A., Helena, Mont.
Swan, G. J., Topeka, Kan.
Sweetman, M. M., Kansas City, Mo.
Talbot, Frank, Danville, Va.
Taylor, J. B., Watertown, N. Y.
Tenney, A. B., Boston, Mass.
Terhune, C. F., New York, N. Y.
Terry, H. W., Jr., Ossining, N. Y.
Thomson, G. W., Philadelphia, Pa.
Thomson, W. H., Jr., Peoria, Ill.
Thwing, O. O., Fort Wayne, Ind.
Tincher, T. S., Washington, D. C.
Tuttle, W. B., San Antonia, Texas.
Underhill, H. L., New York, N. Y.
Van Ness, L. G., Memphis, Tenn.
Vincent, G. I., Des Moines, Iowa.
von Maur, J. D., St. Louis, Mo.,
Welsh, W. J., New York, N. Y.
Whipple, H. S., Rockford, Ill.
Whittaker, A. D., Atlanta, Ga.
Whitton, W. H., St. Louis, Mo.
Whitwell, L. M., Milwaukee, Wis.
Wilde, Charles, Chester, Pa.
Williams, L. S., Harrisburg, Pa.
Wilson, W. A., Rockford, Ill.
Witherby, E. C., Syracuse, N. Y.
Wood, Stuart, Philadelphia, Pa.
Worthing, L. E., Detroit, Mich.
Young, J. T., Muskegon, Mich.
Young, R. W. H., Pittsburg, Pa.
Zeek, C. F., Pensacola, Fla.

ASSOCIATE.

Aikin, H. C., Rockford, Ill.
Asendorf, C. F., Chicago, Ill.
Atwater, C. G., New York, N. Y.
Azoy, A. C. M., New York, N. Y.
Behringer, E. A., New York, N. Y.
Bigelow, L. S., Buffalo, N. Y.
Bingham, R. W., Chicago, Ill.
Buckley, J. C., Chicago, Ill.
Carpenter, H. A., Pittsburg, Pa.
Cartwright, H. R., Phila., Pa.
Cavenagh, Frank, Chicago, Ill.
Claiborne, C. H., Baltimore, Md.
Clifford, T. C., Pittsburg, Pa.
Cressler, A. M., Fort Wayne, Ind.
Cressler, G. H., Fort Wayne, Ind.
Dickey, E. S., Baltimore, Md.
Dougherty, C., New York, N. Y.
Fisher, T. J., Washington, D. C.
Flack, J. D., Orange, N. J.
Fowler, J. S., Philadelphia, Pa.
Frampton, R. C., Pittsburg, Pa.

Garrison, J. J., Albany, N. Y.
Harper, H. D., Chicago, Ill.
Hayward, S. F., New York, N. Y.
Hohmann, A. B., New York, N. Y.
Humphrey, H.S., Kalamazoo, Mich.
Johnston, E. D., Connersville, Ind.
Kellum, B. J., Chicago, Ill.
Little, A. S. B., Nashville, Tenn.
McIlravy, W. N., New York, N. Y.
Marquis, P. S., St. Louis, Mo.
Mason, J. A., New York, N. Y.
Maxwell, J. P., New York, N. Y.
Miller, F. A., Bradford, Pa.
Mueller, Robert, Decatur, Ill.
Norton, A. E., Boston, Mass.
Norton, H. A., Boston, Mass.
Parker, G. W., New York, N. Y.
Peffly, I. W., New York, N. Y.
Plantinga, Pierre, Cleveland, Ohio.
Reynolds, M. G., Anderson, Ind.
Rieha, E. L., Baltimore, Md.
Roberts, C. V., Philadelphia, Pa.
Robus, A. J., St. Louis, Mo.
Rogers, E. H., Philadelphia, Pa.
Sard, R. E., Albany, N. Y.
Sayer, E. Y., New York, N. Y.
Schall, H. D., Detroit, Mich.
Seeger, Robert, St. Louis, Mo.
Speller, F. N., Pittsburg, Pa.
Weart, S. S., Canton, Ohio.
Wharton, Henry, Philadelphia, Pa.
Wickham, Leigh, St. Louis, Mo.
Young, L. B., Detroit, Mich.
Young, N. A., Bolivar, Pa.

JUNIOR.

Carter, R. A., Jr., New York, N. Y.
Cressler, K. M., Fort Wayne, Ind.
Fox, C. J., Darby, Pa.
Gannon, J. J., Vickburg, Miss.
Kingsbury, I. C., New York, N. Y.
Knothe, W. J., St. Louis, Mo.
Mansfield, J. H., New York, N. Y.
Myers, E. B., South Bend, Ind.
Paige, C. E., Malden, Mass.
Rasch, Wm. T., New York, N. Y.

SUMMARY.

Active	236
Associate	54
Junior	10
Total	300

REPORT OF THE BOARD OF DIRECTORS.

The Secretary then read the report of the board as follows:

DIRECTORS' REPORT.

October 18th, 1911.

To the American Gas Institute.

GENTLEMEN: The Board of Directors has the honor to submit its sixth annual report, as follows:

MEETINGS.

Two meetings of the board have been held during the year. A regular meeting August 19th and a regular meeting October 17th.

Committee on Arrangements.

In accordance with by-law 22 the following Committee on Arrangements for the sixth annual meeting was appointed: C. L. Holman, Chairman; D. R. Russell, August Court, C. H. Quackenbush, A. E. Einstein, T. D. Miller, John Dell, C. H. Dickey.

Nominating Committee.

In accordance with resolutions adopted at the fifth annual meeting to the effect that the Nominating Committee should be appointed at least thirty days before the annual meeting, and that alternate members to said committee be appointed, the directors at their meeting of August 19th, appointed the following gentlemen to serve as the Nominating Committee: C. H. Nettleton, Chairman; James H. Jourdan, W. H. Gartley, James Ferrier, J. H. Eustace. And as alternates to the above: E. C. Jones, T. C. Jones, J. D. von Maur, C. M. Cohn, H. M. Moore.

Bulletin of Abstracts.

The publication of the bulletin of abstracts has been continued. The thanks of the Institute are due to the United Gas Improvement Company for furnishing the material for these abstracts.

Membership Committee Report.

The list of new members elected during the year has been as follows:

April, 1911, Election.

Active Membership.

Armstrong, J. H. N., Statistician, Consolidated Gas Company of New York, 4 Irving Place, New York.

Barnum, Dana Dwight, General Manager, Worcester Gas Light Co., Worcester, Mass.

Benson, Frederick Shepard, Jr., Superintendent, Nassau Works, Brooklyn Union Gas Co., 556 Kent Ave., Brooklyn, N. Y.

Bishop, Rookwood Comfort, Secretary and General Manager, Christchurch Gas, Coal and Coke Co., Ltd., Christchurch, New Zealand.

Blackie, John F., Assistant Superintendent, Milwaukee Coke and Gas Co., Milwaukee, Wis.

Blauvelt, William Hutton, Consulting Engineer, Semet-Solvay Co., Syracuse, N. Y.

Bogert, W. Russell, Special Representative, Consolidated Gas Company of New York, 29 E. 21st St., New York.

Bruff, Charles L., Inspector of Machinery, United Gas Improvement Co., 24 N. 22d St., Philadelphia, Pa.

Burcombe, Norman Smith, Secretary, Grays Harbor Gas Co., Aberdeen, Wash.

Cheney, Herbert Neal, Engineer of Construction, Consolidated Gas Co., 24 West St., Boston, Mass.

Clark, Robert Browning, Superintendent, Woonsocket Gas Co., Woonsocket, R. I.

Comstock, C. A., General Manager, Gas and Electric Co., Watertown, Wisconsin.

Cornine, Marshall, Superintendent, Repair Shops, Consolidated Gas Co., 21st St. and 1st Ave., New York.

Cross, Charles Alfred, Engineer Williamsburgh Works, Brooklyn Union Gas Co., foot of N. 12th St., Brooklyn, N. Y.

Davis, Albert G., Chief Chemist, Consolidated Gas Co., 435 6th Ave., Pittsburg, Pa.

Duggan, Frank P., Superintendent, Gas Department, Penn Central Light and Power Co., Lewistown, Pa.

Evans, Charles D., Division Superintendent, Philadelphia Co., 435 6th Ave., Pittsburg, Pa.

Fisher, Howell, Asst. Supt., New England Gas and Coke Co., Everett, Mass.

Francklyn, Charles G., President, Central Union Gas Company, 529 Courtlandt Av., New York City.

Furlong, William G., Office Manager, Municipal Gas Co., 12 State St., Albany, N. Y.

Gadsden, P. H., President, Charleston Consolidated Railway and Lighting Co., Charleston, S. C.

Haight, Theodore, Asst. Superintendent, Williamsburgh Works, Brooklyn Union Gas Co., N. 12th St. and Kent Ave., Brooklyn, N. Y.

Hodgson, Joseph Ernest, Manager, Fulton County Gas and Electric Co., Gloversville, N. Y.

Humphreys, Frank Wilder, Manager, Gas Department, Central Hudson Gas and Electric Co., Poughkeepsie, N. Y.

Kennedy, Thomas P., Superintendent, Brooklyn Union Gas Co., 5th and Hoyt Sts., Brooklyn, N. Y.

Lewis, Raymond Chapin, Asst. to Supt. of Holder Distribution, Brooklyn Union Gas Co., 556 Kent Ave., Brooklyn, N. Y.

Lundblad, Oscar J. A., Supt. of Works, Nassau and Suffolk Lighting Co., Hempstead, N. Y.

MacSweeney, Joseph P., Supt., Commercial Department, Rochester Railway and Light Co., Rochester, N. Y.

McClellon, J. M., Supt., New England Gas and Coke Co., Everett, Mass.

McGowan, Henry Eddy, General Manager, The Flatbush Gas Co., 273 Clarkson St., Brooklyn, N. Y.

Mills, Samuel Archibald, Second Asst. Superintendent, Williamsburgh Works, Brooklyn Union Gas Co., Kent Ave. and N. 12th St., Brooklyn, N. Y.

Morris, William Giles, Chief Clerk, Consolidated Gas Co., 4 Irving Place, New York, N. Y.

Murray, John J., Superintendent, Allegheny Heating Co., 435 6th Ave., Pittsburgh, Pa.

Nickerson, Franklin Hezekiah, Chief Statistician, Consolidated Gas Co., 4 Irving Place, New York, N. Y.

Papst, Hilmar Maximilian, General Manager, Portland Gas and Coke Co., Portland, Ore.

Ray, William Daniel, Manager, Northern Indiana Gas and Electric Co., Hammond Ind.

Reed, Joseph A., Asst. General Superintendent, Philadelphia Company, 435 Sixth Ave., Pittsburgh, Pa.

Reinach, Hugo B., Assistant General Supt. Commercial Dept., Consolidated Gas Co., 4 Irving Place, New York City.

Schick, Karl August, Asst. Supt. Commercial Department, Rochester Railway and Light Co., Rochester, N. Y.

Schobel, Frederick A., Superintendent of Distribution, Municipal Gas Co., 1131 Broadway, Albany, N. Y.

Schneider, Philip J., Treasurer, Central Union Gas Company, 529 Courtlandt Av., New York City.

Schwabe, Walter P., General Manager and Superintendent, Gas and Electric Co., Windsor Locks, Conn.

Shaeffer, John Wallace, Supt., The Milwaukee Coke and Gas Co., Milwaukee, Wis.

Shepard, David James, Engineer, Equity Works, Brooklyn Union Gas Co., Maspeth and Porter Aves., Brooklyn, N. Y.

Silverthorn, James C., Gas and Electric Light Co., Evansville, Ind.

Simpson, Henry, Supt., Consolidated Gas Co., 112 W. 42d St., New York City.

Snyder, Harry L., President, New York and Queens Gas Co., 244 Jackson Ave., Long Island City.

Soult, George H., Supt., Gas Co., Ridgewood, N. J.

Stone, C. H., Manager Gas Department, Orange County Lighting Co., Middletown, N. Y.

Strange, Harry Latimer, Manager, Honolulu Gas Co., Ltd., Honolulu, Hawaii.

Uhlig, Edward C., Chief Chemist, Brooklyn Union Gas Co., 5th and Hoyt Sts., Brooklyn, N. Y.

White, John T., Chief Clerk, Street Main Department and Asst. Supt., Brooklyn Union Gas Co., 5 Skillman St., Brooklyn, N. Y.

Young, Robert W. H., Superintendent of Works, Consolidated Gas Co., 435 Sixth Av., Pittsburgh, Pa.

Associate Membership.

Balz, George Adam, Contracting Engineer, with Didier-March Co., 30 Church St., New York City.

Carpenter, Frank, Commercial Dept., Welsbach Co., Gloucester, N. J.

Cavenagh, Frank, Western Representative, C. H. Dickey & Co., People's Gas Bldg., Chicago, Ill.

Clark, Charles J., Vice-President, Hunter & Dickson Co., 245 Arch St., Philadelphia, Pa.

Daniels, Clarence F., Salesman, Detroit Stove Works, 2921 LaSalle St., Chicago, Ill.

Drew, William Thomas, Vice-President and Superintendent, New York Improved Meter Co., Inc., 306 E. 47th St., New York City.

Flack, J. Day, Engineer Salesman, C. W. Hunt Company, East Orange, N. J.

Hamerstrom, Frederick Nathan, Commercial Department, Welsbach Co., Gloucester, N. J.

Hinman, Walter Hibbard, Gas Meter Engineer, American Meter Co., New York City.

Lewis, Ellis R., President, National Gas Light Co., Kalamazoo, Mich.

Lueder, Carl George, Secretary and Treasurer, New York Improved Meter Co., Inc., 306 E. 47th St., New York City.

McCoy, William P., Commercial Department, Welsbach Co., Gloucester, N. J.

Mead, W. J., Salesman, Detroit Stove Works, 2921 LaSalle St., Chicago, Ill.

O'Neil, W. D., Secretary, Oil and Gas Journal, P. O. Drawer 22, St. Louis, Mo.

Rolston, Robert J., Manager, Welsbach Company, 1008 Filbert St., Philadelphia, Pa.

Smith, T. J., Jr., Special Sales Representative, Pittsburgh Water Heater Co., Pittsburgh, Pa.

Tatman, J. S., with Connersville Blower Company, Connersville, Ind.

Timm, Charles F., Salesman, Wm. M. Crane & Co., Yonkers, N. Y.

Junior Membership.

Callahan, John Joseph, Foreman, New York and Richmond Gas Company, 720 Bay St., Stapleton, S. I.

Crammond, William Alexander, Foreman of Works, Consolidated Gas Co., 337 E. 19th St., New York City.

Creeden, John J., Chief Clerk, General Fuel Appliance Dept., Consolidated Gas Co., 29 E. 21st St., New York City.

Gellert, Nathan Henry, Cadet Engineer, Philadelphia Suburban Gas and Elec. Co., Wyncote, Pa.

Hayward, Harold A., Asst. General Manager, Connelly Iron Sponge and Governor Co., 127 Duane St., New York City.

Heavner, LeRoy Clements, General Foreman, Sioux Falls Gas Co., Sioux Falls, S. D.

Hill, Daniel L., Street Clerk, Toronto Gas Co., 19 Toronto St., Toronto, Can.

Potts, Thomas Swagar, Cadet Engineer, Public Service Gas Co., 188 Ellison St., Paterson, N. J.

Maxwell, Charles E., Jr., Cadet Engineer, Philadelphia Suburban Gas and Electric Co., Chester, Pa.

McCarthy, Albert P., Cadet Engineer, Philadelphia Suburban Gas and Electric Co., Chester, Pa.

Ritchie, Arthur Robson, Assistant Superintendent, Consolidated Gas Co., 14th St. and Ave. C, New York City.

Schick, Conrad, Jr., Assistant Supt., Public Service Gas Co., 258 N. Park St., East Orange, N. J.

Transfers to Active Membership.

Lucena, Joseph, Superintendent of Distribution for the Omaha Gas Co., Omaha, Neb.

October, 1911, Election.

Active Membership.

Anderson, Howard Bruce, Superintendent City District, The United Gas Improvement Co., 1931 S. 9th St., Philadelphia, Pa.

Ball, Samuel, Manager, Bay City Gas Co., Bay City, Michigan.

Barker, Perry, Fuel Engineer, Arthur D. Little, Inc., 93 Broad St., Boston Mass.

Brown, James A., Gas Engineer, with Hodenpyl, Hardy & Co., 1004 Majestic Bldg., Detroit, Mich.

Crutcher, William H., Superintendent, Kentucky Heating Co., Louisville, Ky.

de Castro, Joseph L., Asst. Supt., Consolidated Gas Co., Foot of East 115th St., New York City.

Dillon, Harry J., Superintendent, Brooklyn Borough Gas Co., Coney Island, N. Y.

Estberg, Howard C., Manager, Greely Gas and Fuel Co., Greeley, Col.

Folsom, Robert Morse, Second Assistant Superintendent, New England Gas and Coke Co., Everett, Mass.

Foshay, W. B., Manager, Washington-Oregon Corporation, Vancouver, Wash.

Hine, Willard Foster, Chief Gas Engineer, Public Service Commission for the First District, New York Tribune Bldg., New York City.

Hone, Frederic deP., Consulting Engineer, 1 Liberty St., New York City.

Hyde, Edward Bolton, Superintendent Commercial Department, New Amsterdam Gas Co., 22 East 22d St., New York City.

Keal, George I., Superintendent Construction, Detroit City Gas Co., Detroit, Mich.

Kubo, Shosuke, Managing Director of Kobe Gas Co., Ltd., Kobe, Japan.

Livingston, Robert E., Advertising Manager, Consolidated Gas Co., 1 Madison Ave., New York City.

Lucas, Thomas J., Consulting Engineer, Assistant to W. A. Baehr, 2009 People's Gas Bldg., Chicago, Ill.

Luckenbach, Charles A., Manager of Construction, Los Angeles Gas and Electric Corporation, 645 S. Hill St., Los Angeles, Cal.

Macklin, A. Fred., Assistant Superintendent, Consolidated Gas Co., 44th St. and North River, New York City.

Nettles, Rosco, Secretary, Tampa Gas Co., Tampa, Fla.

Philbrick, Joseph E., General Manager, York Gas Co., York, Pa.

Snyder, Albert I., Superintendent of Manufacture, Grand Rapids Gas Light Co., Grand Rapids, Mich.

Tincher, T. Symmes, Superintendent West Station, Washington Gas Light Co., 26th and G Sts., Washington, D. C.

Way, Alexander B., Chief Chemist, New England Gas and Coke Co., Everett, Mass.

Wills, John Valentine, Superintendent, Macon Gas Co., Macon, Ga.

Worthing, Leigh E., Chief Chemist, Detroit City Gas Co., Detroit, Mich.

Associate Membership.

Annett, Edward Burdett, Inspector of Gas, State of New Jersey, 738 Broad St., Newark, N. J.

Herbert, Frederick D., General Sales Manager, Terry Steam Turbine Co., 90 West St., New York City.

Hohmann, August B., Sales Manager, C. J. Tagliabue Mfg. Co., 396 Broadway, New York City.

Robus, Albert James, Engineer, Evens & Howard Fire Brick Co., 920 Market St., St. Louis, Mo.

Wilson, John Crosier, Engineer, Thomas Meter Dept., Cutler-Hammer Mfg. Co., Milwaukee, Wis.

Junior Membership.

Chidsey, Raymond F., Cadet Mechanical Engineer, Philadelphia Suburban Gas and Electric Co., Wyncote, Pa.

Duncan, Ronald Bruce, Asst. Supt. Spring Garden District, Philadelphia Gas Works, 1313 Wakeling St., Frankford, Philadelphia, Pa.

Field, Horace Hopkins, Asst. to Supt., Haverhill Gas Co., Haverhill, Mass.

Haldeman, Clifford L., District Main Foreman, Philadelphia Gas Works, 3429 Helen St., Philadelphia, Pa.

Hamilton, Earl R., Chemist, Providence Gas Co., Providence, R. I.

Kane, Milford L., Service Foreman, Omaha Gas Co., 1509 Howard St., Omaha, Neb.

Patterson, Clement F., General Foreman Mains and Services, Omaha Gas Co., 1509 Howard St., Omaha, Neb.

Pfeiffer, Bernard V., Cadet Engineer, Omaha Gas Co., 1509 Howard St., Omaha, Neb.

Robinson, Chauncey D., Cadet Electrical Engineer, Philadelphia Suburban Gas and Electric Co., Wyncote, Pa.

Sheehy, John Charles, Service Foreman, Frankford District, United Gas Improvement Co., 4623 Penn St., Frankford, Philadelphia, Pa.

Titzel, R. John, Gas Engineer, Lancaster Gas Light and Fuel Co., Conestoga Bldg., Lancaster, Pa.

Woodroffe, William P., District Main Foreman, Philadelphia Gas Works, 31 W. Johnson St., Germantown, Philadelphia, Pa.

Transfers to Active Membership.

Kellogg, Raymond, C., Engineer, Assistant to Superintendent, Brooklyn Union Gas Co., 5 Skillman St., Brooklyn, N. Y.

Otten, Jr., Charles, Superintendent, Westchester Lighting Co., 119 Woodworth Ave., Yonkers, N. Y.

Schiller, Charles C., Superintendent of Meters, People's Gas Light & Coke Co., 122 Michigan Blvd., Chicago, Ill.

von Vittinghoff, Hans, Superintendent, Haverhill Gas Light Co., 284 Winter St., Haverhill, Mass.

Willis, Charles Moore, Engineer of Distribution, Old Colony Gas Co., Weymouth, Mass.

At the April election there were added:

Active members	54
Associate members	19
Junior members	12
Total	85

At the October election there were added:

Active members	26
Associate members	5
Junior members	12
Total	43

Making a total of 128 new members for the year.

SECRETARY'S REPORT ON MEMBERSHIP.

Total membership at beginning of year		1348
New members elected		128
		1476
Members died	15	
Members resigned	34	
Members dropped for non-payment of dues	44	
		93
Present membership		1383

Secretary's Report on Badges and Proceedings.

Badges:

On hand Sept. 1, 1910		60
Purchased for stock		50
		110
Sold		36
On hand Sept. 1, 1911		74

Proceedings:

Volumes I, II, III and IV.		
In stock September 1, 1910		943
Sold during year		38
In stock September 1, 1911		905
Volume V.		
Received from printer		1,700
Sent to members	1,284	
Sent in exchange	60	
Sold during year	18	
		1,362
In stock September 1, 1911		338

Treasurer's Report.

October 18, 1911.

To the Board of Directors.

Gentlemen: I have the honor to present herewith the rereport of the Treasurer, for the fiscal year ending August 31, 1911.

Receipts.

Back dues	$ 770.00
Current dues	10,785.00
1912 dues in advance	30.00
Initiation fees	1,540.00
Bulletin of abstracts	1,324.15
Badges sold	135.00
Proceedings sold	317.00
Miscellaneous sales	86.89
Interest on bank balances	196.37
Total receipts	$15,184.91

Expenditures.

Publishing bulletin of abstracts	$ 1,594.31
Rent, offices and store room	1,599.80
Printing and stationery	318.81
Reporting meetings	240.20
Premium on surety bond	40.00
Book cases for library	33.75
Publishing and shipping proceedings	3,046.34
Subscription Gas Educational Fund	350.00
Advertisement in Iowa proceedings	25.00
Printing advance papers	605.69
Expenses New York meeting	563.70
Salary, Secretary-Treasurer	3,000.00
Salary, stenographer	900.00
Miscellaneous expenses	325.61
Total expenditures	$12,643.21

Summary for the Fiscal Year.

Total receipts		$15,184.91
Total disbursements		12,643.21
Surplus for fiscal year		$ 2,541.70
Balance on hand first of year		4,316.29
Surplus September 1, 1911		$ 6,857.99
Balance in Columbia Trust Company as per bank statement, 8-31-'11	$ 6,853.50	
Less outstanding check No. 413	3.60	
	$ 6,849.90	
Cash in hands of Treasurer, 9-1-'11	8.09	$ 6,857.99

SUPPLEMENTAL REPORT.

Cash Statement Sept. 1 *to Oct.* 14, 1911.

Balance September 1st	$6,857.99
Received from dues, etc.	2,558.02
	$9,416.01
Expenditures to October 14th	2,624.75
Balance October 14th	$6,791.26

Statement of Outstanding Accounts.

September 1, 1911.

Delinquent for one year's dues (year ending August 31, 1911, as per list.)

Active	103	at	$10.00	$1,030
Associate	25	at	10.00	250
Junior	11	at	5.00	55
				$1,335

Delinquent for two years' dues. (Two years ending August 31, 1911, as per list.)

Active	57 at	$20.00	$1,140
Associate	13 at	20.00	260
Junior	8 at	10.00	80
			$1,480

Delinquent for bulletin of abstracts.

For one year ending November 30, 1911,	22 at	$ 5.00	$110
For two years ending November 30, 1911,	13 at	10.00.	130
			$240

Delinquent for miscellaneous sales.

Sale of proceedings, 4 vols. at $5.00 .... $20

Summary.

Delinquent dues, one year	$1,335
Delinquent dues, two years	1,480
Delinquent for abstracts	240
Delinquent for miscellaneous sales	20
	$3,075

No liabilities except for current bills.

Report of Finance Committee.

October 17, 1911.

To the Board of Directors, American Gas Institute.

Gentlemen: Enclosed please find the report of the Treasurer, for the fiscal year ending August 31, 1911. Your Finance Committee has audited the books, accounts and statements of the Treasurer, and has found the report to be correct.

Respectfully submitted,

(Signed) J. B. Klumpp, *Chairman.*
W. R. Addicks,
W. G. Africa.

Report of Technical Committee.

The Technical Committee has submitted the papers and committee reports for this meeting as listed on the program. These have been approved by the directors for reading at this meeting. The directors have engaged Professor W. A. Bone, of Leeds University, England, to deliver a lecture on "Surface Combustion" during this meeting.

Life Membership.

The directors, by a unanimous letter ballot, have made A. B. Slater a life member of the Institute, in recognition of his presentation to the Institute Library of his valuable collection of gas books, periodicals and pamphlets.

Contribution to the Gas Educational Fund.

The directors recommend that the Institute contribute the sum of $350.00 to the Gas Educational Fund.

General Recommendations.

The directors make the following recommendations to the members:

1. That the number of papers to be presented and discussed at future annual meetings be limited to ten (10).

2. That a committee be appointed to consider and report on the standardization of gas works apparatus; such as works fittings, valves with uniform width across the flanges and standard tests of same: manholes and handholes; covering uniform design as to general dimensions, thickness of flanges, bolt holes, etc., etc., and another committee to consider and report on allowed strains in the designs of gas holders and to purchase standard specifications covering tensile strength, elastic limit bending tests of light steel plates and sheets, structural steel, rivets, etc., and minimum thickness of plates.

3. That the editor of the Wrinkle Department for the coming year be requested not to solicit new wrinkles but to examine and edit all the wrinkles that have been presented to the Institute and its preceding associations. And that he classify

and index them, after rejecting those that have been found to be impractical or obsolete.

4. That a committee be appointed to consider and report on the development of a small unit gas engine.

5. That it is the sense of the directors that the Institute should publish and distribute to the members at intervals during the year a bulletin that will acquaint the members with the general affairs of the Institute and embody any specific information which may be of interest to the members.

6. That the Secretary be instructed to ascertain the present status of all the state and district gas associations in the United States, and report on the prospect of inducing those not already affiliated to become affiliated with the Institute.

Respectfully submitted for the Board of Directors.

(Signed)

DONALD McDONALD, *President.*
A. B. BEADLE, *Secretary.*

THE PRESIDENT: Gentlemen, you have heard the report of the directors. What is your pleasure? I should like to hear a motion to receive it and to concur in the recommendations, unless there are some who do not wish to concur.

A motion was duly carried that the report of the Board of Directors be received and that the Institute concur in the recommendations made by the directors.

PRESIDENT'S ADDRESS.

Before reading his address, the President called upon in turn the First Vice-President, Mr. Morris, and the Second Vice-President, Mr. Shattuck, to take the chair, and neither of these gentlemen being in the room, called upon Mr. Henry L. Doherty to take the chair.

The last mentioned gentleman took the chair while the President read his address, as follows:

Every organism, from the smallest of the microbes to the vastest of the nebulae, seems to follow the general law that during the early stages of development changes are rapid and

marked. When maturity is reached, changes become less perceptible. The gas business is now about one hundred years old and a single year is too short a time in which to expect that any great changes will be made. Of course, improvements are announced every year, and their inventors are apt to be very sanguine about them; but until the test of time and of actual practice is applied to them, no one can say whether or not they are really improvements.

The last year has brought a good deal of confirmatory evidence as to the excellence of vertical retorts; but it has, at the same time, brought forward the question as to whether or not chamber ovens or by-product ovens accomplish everything which is claimed for the vertical retorts, besides possessing considerable advantages of their own. The Technical Committee promises up to date information on these subjects, and I shall not attempt to anticipate the papers which will be read.

The idea of public control of public utilities has gained considerable ground during the last year, but at the same time it seems to have become much more reasonable. Control by state commissions is now looked upon by gas men with the hope that the commissions may be composed of reasonable men of sufficient business experience to understand the problems which confront the business, rather than of politicians who hope to win the favor of the multitude by attempting to require the companies to make bricks without straw. In exchange for public control it seems reasonable to hope that the states will provide such immunity from destructive competition as will compensate for such additional burdens as it imposes. It seems only reasonable that when the state says to the gas company that it can only earn a certain interest on its actual investment, it ought, at the same time, to use its authority as far as possible to take the business out of the category of hazardous enterprises. Competition is by no means the only hazard which besets the business, but it is the one which the state, and the state alone, can remove. Another hazard which the state could greatly mitigate is the continual threat of ruin-

cus verdicts in damage cases. The companies do not ask to be relieved from paying just compensation for any injury that may arise through their negligence or misfortune; but to be continually harassed with claims for imaginary injuries, and to be mulcted for damages out of all proportion to injuries actually received, is certainly a hazard which the investor will have in mind in fixing the price which he will pay for securities, and which the manager can never forget in making up his estimates of what it costs to deliver gas.

I believe, on the whole, that the attitude of the public is becoming distinctly more favorable. This may be because agitation has served to educate, to some extent, those who are not wilfully blind, and it may be because the investigation and prosecution of the large industrial combines has, for the time being, led the scent away from the much hunted public utilities.

The papers which will be read cover almost every phase of the gas business. It is to the Gas Institute itself that I propose to devote the most of the time which a presidential address is expected to occupy. There are a few members of the Institute who feel that it does not accomplish the purpose for which it was organized. There is a considerable number of members who feel that the work which it does do might be done more efficiently.

I think that it will be admitted that the membership of the Institute comprises very nearly all of the men engaged in the gas business in North America, whose experience, whose ability, and whose opportunities would enable them to contribute anything of value to the work of the Institute. Nearly all of these gentlemen are enough interested in the work of this body to leave their homes and attend its meetings. Many of them are willing to undertake the labor and responsibility incident to the service on committees, and the preparation of papers. If the willing coöperation of so many able men does not produce the proper results, then it is a reproach to a very large part of the membership, for it must be borne in mind

that many of our members are men whose business in life is to organize, to combine the labors of many persons, and to secure the best results from such combined efforts. I am one of those who feel that the Institute has done a great work in the past, that it is doing a great work now, and that it will continue to do a great work in the future. When I speak of the Institute, I speak of it as the legitimate heir of the three associations from which it was made, and of the various state associations which owe their existence to it, or to the earlier bodies out of which it was formed.

When it is realized that but for the Gas Institute, in this broad scheme, there would be practically no text books on American Gas Engineering, that each company would have had to depend on its own experience for all improvements we will realize the work which the various associations have done and are doing for the gas business. Let each man recall to mind the many devices which are producing revenue and saving money for the companies which he represents, and then ask himself what proportion of them were suggested by words heard or papers presented at some of the association meetings. He will then realize the debt which his company owes to the gas associations. For my own part, I believe that the work of the various associations and of the Gas Institute, to which the efforts of all of them finally come, is worth more to the ordinary gas company than an engineering department of its own, costing many thousand dollars each year, and doing the best that it could, but without the reports of the work done in other places which the Institute furnishes.

It ought, however, to be the aim of all of us to make the Institute the most efficient body possible; and in order to work intelligently towards this end, it is necessary that there should be some agreement as to how the end can be accomplished. All progress is the working towards an ideal, and before progress can be made along any definite lines, the ideal aimed at must first be pretty clearly defined. I know of no way in which men can agree on any proposition except that some one

should state the proposition, see how many will agree with it, and then change it and discuss it until it meets the views of the majority. As a step in this direction, I am going to state my own ideal of what the American Gas Institute shoud be.

I believe that it should combine the functions of a Social Club, a Trades Union, and a Society for Scientific Research. A Social Club in that it enables its members to meet agreeable gentlemen who are interested in the same subjects that oneself is interested in; a Trades Union in what the combined influence of all the membership can be brought to bear to secure any lawful and equitable advantage, or to resist any unjust or illegal measure; a Society for Scientific Research in that it preserves and lays before its members full reports of everything that is done in applied science, so far as it relates to the gas business.

Little need be said concerning the first two functions. Most of us find the Institute a very agreeable club, and most of us would feel lonely indeed if we were deprived of the friendships which have grown out of its meetings. Concerning the Trades Union idea, the laws which bless or blight our business are not national laws, they are state laws, and the most that the Institute can do is to point out to the companies in each state what has been done in other states, and how laws of various sorts have worked in practice. Experience has shown that information of this sort, presented at the right time, has proved the most powerful weapon for preventing the passage of bad laws.

It has been suggested that the Institute could, in some way, arrange for the better protection of the vast financial interests represented by its members; that something could be done towards discouraging the formation of competitive companies in localities which are already well served by existing companies. The laws of some states which have created public utility commissions have provided for this matter in a very fair and just way. The present is a very bad time for this body or any other organization to make any move

which could possibly be made to appear as a combination in restraint of trade. It is a fact, however, that every member of this Institute is a guest in any gas works which he chooses to visit. He is allowed to see all processes, he is informed as to costs and figures. That he should afterwards use information acquired in this way to the detriment of the companies supplying it, is certainly a violation of the laws of hospitality; and if there is any doubt at present that such conduct would be condemned by the public opinion of this body, then that doubt should be removed. Generally speaking, however, the American gas companies not only have no secrets, but their attitude is that of beseeching the people to inform themselves as to the business and in this way become convinced that the service which they render is an honest service, worth all that it costs to the consumer, and a service which costs the company so much as to leave only a fair margin of profit over and above that cost.

In order to perform its functions as a society for Scientific Research, I do not believe that the Institute should attempt, through committees or otherwise, to engage in original investigation. Every subject which can be of importance to a gas man becomes acute at some time or other in the various works in which our members are employed. When such questions become acute, they are investigated by men who have the keenest interest in their solutions, who have a gas works in which to try experiments, and who have trained assistants, ready and willing to carry out suggestions. Certainly the Institute itself cannot get work done under more favorable circumstances, and when the work is finished and a complete report of it published in our proceedings, it is the best that we can hope to do. It is, in my opinion, something very well worth the doing, but something to which we have all become so accustomed that our appreciation of it has been somewhat dulled.

I can see no advantage to be gained either by a very large membership or by a very large revenue. When our member-

ship includes all the men in North America who are able to bring something to the meetings and take something away from them, then it would be worse than useless to try to make the membership any larger. When our revenues are great enough to pay all of our legitimate expenses, to prevent the Institute from becoming a burden on any of its friends—whether they be printers, manufacturers, or those in whose homes we decide to meet—then I think that its revenues are large enough. I include as legitimate expenses the bringing before our members as lecturers those eminent scholars whose work serves to advance the boundaries of science so far as it is applied to our own business. I have heard the suggestion made that the Institute ought to advertise gas in the magazines of national circulation. It must be remembered that a very large proportion of the readers of these magazines live in the country and in small towns, where they could not get gas if they wanted it. I think it evident, therefore, that money spent for advertising which reaches more directly the people that it hopes to reach would be better spent; and in short that the local gas companies who are to profit by this advertising are the parties to furnish the money and to control its expenditure. Money spent locally not only reaches the people which it is desired to reach, but also does its part towards making friends for the company where it needs friends—that is, at home.

I know that it seems somewhat eccentric to say that the Institute does not want either money or members; but I believe that a mad race either for a large membership or a large revenue is apt to destroy much that is most valuable in a body such as this. As I said above, we have no use for, and should take no pride in, any larger membership than that which takes in all the desirable men in our territory, nor any larger revenue than that sufficient to accomplish the objects for which the Institute exists.

The principal object is the promotion of the best interests of the members and of the companies which they represent.

The report of the secretary has shown the condition of the Institute as to membership and as to finances. I consider that condition excellent and the outlook for the future most encouraging.

MR. DOHERTY (in the Chair): It is not customary to discuss the President's address immediately, but to appoint a committee of three to consider the address and report at a later session. If anybody will make the usual motion, the Chair will put it.

A motion was duly carried that a committee of three be appointed to consider the President's address and report at a later session.

MR. DOHERTY: The temporary chairman appoints as a committee:

Messrs. A. P. Lathrop, W. A. Baehr and James W. Dunbar.

At this point the President resumed the chair.

REPORT OF NOMINATING COMMITTEE.

On behalf of this committee its chairman, Mr. Charles H. Nettleton reported as follows:

The committee unanimously reports as follows:

For President, Honorable I. C. Copley, of Aurora, Ills.

For First Vice-President, V. F. Dewey, of Grand Rapids, Mich.

For Second Vice-President, E. N. Wrightington, of Boston, Mass.

For Secretary and Treasurer, Mr. Beadle sent a communication to the committee stating that he would prefer to withdraw and give up the work, owing to his own outside work. In consequence the committee nominates.

For Secretary and Treasurer, George G. Ramsdell, of New York.

For directors to serve two years

C. L. Holman, of St. Louis.

George McLean, of Dubuque.

Alten S. Miller, of New York.

Rollin Norris, of Philadelphia; and
Richmond E. Slade, of New Orleans.
On behalf of the committee,

CHARLES H. NETTLETON,
Chairman.

THE PRESIDENT: You have heard the report of the Nominating Committee. What is your pleasure?

MR. E. G. PRATT: I move that the Secretary be directed to cast the ballot of the Association in favor of the names of the gentlemen as read.

The motion was seconded.

THE PRESIDENT: Before that motion is put I will appoint three tellers—Mr. Searle, Mr. Humphreys and Mr. Pratt.

Gentlemen, it has been moved and seconded that the Secretary be instructed to cast one ballot for the nominations as made by the Nominating Committee. All of those in favor of that motion signify by saying aye. (AYES). Contrary, No. (No response.) The motion is unanimously carried.

THE SECRETARY: Mr. President, I cast a ballot of the Institute for the names submitted by the Nominating Committee.

THE PRESIDENT: I should like to hear from the tellers.

MR. SEARLE: The tellers announce the election of officers as read.

THE PRESIDENT: Gentlemen, the tellers having reported that the nominees have received the unanimous vote of the Institute, I declare them to be elected the officers of the Institute for the ensuing year. I should like to hear from Mr. Copley. Is Mr. Copley present?

MR. COPLEY: Mr. President and fellow members of the American Gas Institute—I want to thank you from the bottom of my heart for this honor which you have conferred upon me. I am going to do the best that I possibly can to merit your good will next year as well as on this occasion, and if I fall down, I hope to be able to throw the responsibility

on to some one else. I will not take any more of your time now other than to again express my thanks.

The President: If Mr. Dewey can get away from the work he has been doing lately, we should like to hear from him.

Mr. Dewey: I wish to thank the Nominating Committee and members of the Institute for the honor conferred. I trust that I shall be able to discharge the honorous duties—duties of the Vice-President, I understand are very light. The only thing I have to do, I believe, is to preside in case Mr. Copley is run over by the Democratic band-wagon. That I trust is not likely. Thank you.

The President then called on Mr. Wrightington to speak, but that gentleman not being present, the next order of business was proceeded with.

Committee on Next Place of Meeting.

The President: Next in order is the appointment of a committee on the next place of meeting. I will appoint on that committee Mr. Alten S. Miller, Mr. A. P. Lathrop and Mr. Rollin Norris.

The reports of the committees are now in order.

Public Relations Committee.

The President: Has the Public Relations Committee any report to make? Mr. Williamson is the chairman of that committee. Is he present? I do not think they have any report to make as they are not here to make it.

Report of the Technical Committee.

On behalf of the Technical Committee the following report was made by

Mr. Dewey: On behalf of the Technical Committee I shall submit the list of papers you have before you in the printed program. I should like to answer that there was one paper that will not be presented, the one on Pacific Coast Conditions.

The President: Gentlemen, when you get into the report of the Technical Committee you will find it is a very fine report and has involved great labor in preparing it. I think the thanks of the association are due in a very large measure to Mr. Dewey for the labor he has put on it.

Report of the Committee on Calorimetry.

Mr. Klumpp, the chairman of the Calorimetry Committee, read the following report:

Report of Calorimetry Committee of American Gas Institute, 1911.

The report of the Calorimetry Committee for the year 1911 must follow somewhat the lines of the report presented last year—namely, one of progress.

While considerable experimental work has been done, the results are not conclusive enough to permit of publishing completely the data obtained during these tests. We are including, however, some few recommendations that we think will be of value.

The experimental work during the last year has included the time of two engineers covering a period of nearly three months. This work was done at the University of Wisconsin, Madison, Wis., by J. N. Lawrence, under the supervision of O. L. Kowalke, and at the Philadelphia laboratories of the United States Gas Improvement Company by Maurice S. White, under the supervision of J. B. Klumpp.

The laboratory work consisted of testing for general efficiency a Parr gas calorimeter, submitted and loaned by the Standard Calorimeter Company, East Moline, Ill.; a Doherty gas calorimeter, submitted and loaned by the Improved Equipment Company, of New York; an improved Junkers calorimeter, purchased from Junkers & Company, Dessau, Germany, and a calorimeter of the Junkers type, purchased from the American Meter Company, of New York.

The results obtained with some of these new type instruments, as reported by the two laboratories, do not exactly coin-

cide, and, while the errors obtained are not excessive, the discrepancies are great enough to warrant a continuance of the investigation as to the accuracy of these instruments in reading correctly the calorific value of the gas. However, the work has progressed sufficiently to warrant our making certain general statements as to some of the relative merits of these calorimeters.

That of the American Meter Company gives results sufficiently correct for general use and adoption by the members. This instrument embodies the general design of the original Junkers instrument, and seems to have included the elements that have given that calorimeter its general high efficiency. It is modified, however, according to the recommendations submitted in the committees' reports for the years 1908 and 1909, and is provided with accessories that read directly the heating value, making all measurements in English units.

The results of the two investigations on the Doherty calorimeter have not exactly coincided, and, while they have indicated that this instrument gives exceedingly close readings to those obtained on the Junkers, we feel that our work should be carried somewhat further before any definite statement is made.

In the report of the committee in 1908 it was recommended that the thermometers reading the temperature of the inlet and outlet water be placed on the same level. Such a type of instrument was purchased from the Junkers Company, Dessau, Germany, and the tests on this one calorimeter do not accord with their original type of calorimeter, but were found to be two or three per cent. lower. This error, it is believed, is caused by a modification of its interior and exterior construction and not by the change of position of the thermometers.

The Parr gas calorimeter represents an entirely different method of obtaining the heating value of the gas. It is a dual calorimeter, and with it a comparison is made between the heating value of the gas to be measured and a gas of a supposedly known heating value. The design and operation of

this instrument introduces elements that are not conclusively substantiated, and the results of the observations on this instrument by the two laboratories have been somewhat at variance. It is therefore considered advisable to continue this work to determine, if possible, the cause of these discrepancies. Therefore, additional tests will be made, and will be compared with those now being undertaken by the Bureau of Standards.

Further, the work of the committee has been devoted towards checking the variations introduced by changing atmospheric conditions, and also towards determining the most advisable rate of gas consumption in some of the calorimeters under investigation. The results did not vary perceptibly from the statements submitted to the Institute in previous reports.

During the past year your committee has been in touch with the Bureau of Standards at Washington, which has been conducting a very complete examination into the subject of gas calorimetry. The bureau has obtained instruments of many makes, and the investigation is proceeding along lines, the results of which, when made public, will be invaluable to the gas industry. This work has been undertaken by the bureau at the request of gas interests, and particularly at the request of the American Gas Institute.

After a conference with Dr. E. B. Rosa, Acting Director of the bureau, and a visit to the laboratories, we are led to believe that it will be wise for us to submit a progress report until we can learn that the result of this work, which is being made along lines parallel to the work done by your committee in the past.

We wish to submit to the Institute a letter which has just been received from Dr. Rosa in which he states that so far as their work has gone their conclusions agree in the main with those reported by your committee. A copy of this letter is attached, as it outlines the work that the bureau has undertaken in this field of research.

The Bureau of Standards, in its investigation up to this

time, has called to our attention some features that should tend to increase the efficiency of operation, and which we thought wise to bring to your consideration.

One of these matters is the application of a set of baffle plates to the Bunsen burner in the Junkers type of calorimeter, that will tend to prevent loss of heat by reducing the downward radiation from the gas flame. These plates, three in number, are constructed of light metal with several holes to allow admittance of air; they are slipped over the stem of the Bunsen burner and placed about an inch apart, the upper one being about one inch below the top of the burner.

The lower plate is flat and extends to within one-eighth to one-fourth of an inch of the walls of the combustion chamber. The two upper plates are conical in form and are placed with the apex down, the middle one having a somewhat larger diameter than the upper one, but less than the lower or horizontal plate. These baffles should each have four or five holes about one-half inch in diameter, which, with the space between the plate and the combustion chamber, will permit of the passage of sufficient air for perfect combustion of the gas.

Such a scheme has increased the readings of some instruments investigated by the Bureau somewhat higher than one per cent., and should be generally adopted.

The sketch adopting Dr. Rosa's letter will assist the operator in constructing these screens where their purchase cannot be made.

For the best and most accurate work, and especially where the readings of the calorific power of the gas are made to comply with some regulatory order it is always advisable to select the best grade of thermometers. These should be calibrated and the correction, if any, applied to the temperature reading.

One manufacturer of thermometers has brought up the subject of the stem correction, that it is necessary to apply if the thermometer is calibrated when completely immersed, which is the general practice, and that adopted by the Bureau of

Standards. The stem correction is applied when the stem of the thermometer is exposed and at a different temperature from the immersed bulb. Such a correction is not usually necessary on the thermometer indicating the temperature of the inlet water, as this water, when operating under the directions formerly prescribed, is at the temperature of the room. However, the thermometer indicating the temperature of the outlet water has a stem temperature of probably fifteen degrees below the bulb temperature, and therefore, a correction should be made for the difference in expansion between the mercury and the glass.

The usual correction for a thermometer indicates the error in the reading when the thermometer is completely submerged, as compared with a standard thermometer, under the same conditions, and this correction can be readily applied for any point in the thermometer scale from the correction curve accompanying the thermometer. The correction for the emergent stem is somewhat more complicated, and can be explained in no better way than to refer to Form 44, issued by the Bureau of Standards.

A copy of this form is as follows:

Correction for Emergent Stem (Thermometer).

"In general, all corrections are determined for total immersion, *i. e.*, for the condition where both bulb and stem of the thermometer are at the same temperature. If, however, the stem is emergent into space either hotter or colder than the temperature of the bulb, a stem correction must be applied to the observed reading in addition to the correction given in the accompanying table.

"This so-called stem correction is very large if the number of degrees emergent and the difference of temperature between the bath and the space above it are large. It may amount to more than 20°C. for measurements made with a mercury thermometer at 400°C. (750°F.).

"For the glass of which this thermometer is made the stem correction may be computed from the following formula:

Stem correction equals 0.000088 $\times$ *n* (T— *t*)
n equals number of degrees emergent from the bath
T equals temperature of bath;
t equals mean temperature of the emergent stem.

"The mean temperature, *t*, may be approximately measured by means of a small auxiliary thermometer suspended near the emergent stem, or by surrounding the latter with a small water jacket and taking the temperature of the water with the auxiliary thermometer, or, more accurately, in the way suggested by Guillaume, by exposing an exactly similar stem and capillary mercury thread beside the emergent stem and thus measuring its mean temperature. This is also conveniently carried out with the 'thread thermometer' (Fadenthermometer) of Mahlke, in which the expansion of the mercury in the capillary tube (bulb) is measured on a still finer capillary stem.

"Example: Suppose that the observed temperature was 85° and the thermometer was immersed to the 32° mark on the scale, so that 53° of the mercury column projected out into the air, and the mean temperature of the emergent column was found to be 70°, then

Stem correction = 0.000088 $\times$ 53 (85 — 70 = 0.07.

"As the stem was at a lower temperature than the bulb, the thermometer read too low, so that this correction must be added to the observed reading to find the reading corresponding to total immersion, *i. e.*, 85.00 ÷ 0.07 = 85.07. From the accompanying table of corrections it is seen that a further correction of 0.12 must be applied to the reading of the thermometer at this temperature, so that the correct temperature is 85.07 ÷ 0.12 = 85.19."

In connection with the work this year we have commenced an investigation into the merits and defects of the small wet gas meter, which is in general use with most calorimeters, and also with most photometers. Our plan is to determine, if possible, first the error caused when the gas passing through the meter differs in temperature from the water in the meter;

second, the effect caused by gases of different degrees of saturation, and third, the degree of accuracy with which the meter may be commercially relied upon to register.

There have been several calorimeters called to our attention by members as well as manufacturers, which present exceedingly interesting features, but which we have not been able to look into. We refer more particularly to instruments of the recording type, but we would advise our members to adopt them with extreme caution. Instruments of this type, while giving comparative results, do not, as a rule, give correctly the actual heating value of the gas, as determined by their indications, and such instruments should not be used for obtaining readings for inspection or regulatory purposes.

On account of the unfinished condition of the work that has been in progress this year, we suggest that the Committee be continued and be allowed to carry on the investigation during the coming year. If this is done it will also afford the Institute an opportunity to keep in touch with the work now under way at the Bureau of Standards, and also other investigations undertaken by several university authorities.

Respectfully submitted,

R. B. Brown,
Chairman.

Department of Commerce and Labor.
Bureau of Standards.

Washington, October 6, 1911.

Mr. J. B. Klumpp,
1401 Arch Street,
Philadelphia, Pa.

My Dear Mr. Klumpp:

In reply to your inquiry as to the present status of our calorimetric investigations, we beg to submit the following brief report.

Our work as planned may be grouped under three heads:

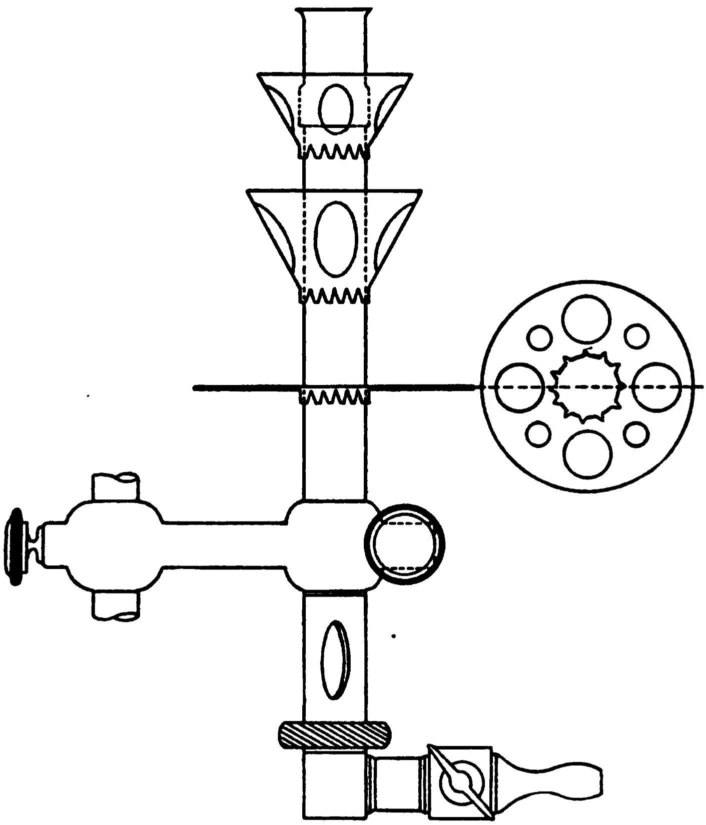
1. The determination of the heats of combustion of a number of pure substances such as sugar, naphthalene, benzoic acid, etc., which the Bureau could then issue as standard combustion samples for use in checking up the results obtained with calorimeters of the Berthelot bomb type. This portion of the investigation is now nearly completed and the Bureau has furnished during the past year a large number of such standard combustion samples to chemists and other technical men. These samples have already done much to reduce the results obtained by different laboratories to a uniform and comparable basis. Enclosed you will find a sample certificate which we issue with these combustion samples, and Bureau Circular No. 11, which contains information concerning these samples and directs attention to important precautions in the use of bomb calorimeters.

2. An investigation of the leading types of industrial gas calorimeters used in this country and abroad, with a view to ascertaining the order of accuracy attainable with the various calorimeters,—the errors to which they are liable, and the necessary precautions that should be observed in their use. Considerable work has been done on this part of the investigation, but we are not yet in a position to render a report that would be of immediate assistance to your committee. We might add, however, that so far as our work has gone, our conclusions in the main are in agreement with the excellent and painstaking investigations of the Committee on Calorimetry of the American Gas Institute.

In addition to the intercomparison of these calorimeters, to determine their relative efficiency, this portion of the investigation will include a comparison with the bomb calorimeter, using several gases, to determine how nearly the results obtained with them are in agreement with the best known absolute values of the heats of combustion.

There is one simple modification or rather addition to the flow calorimeters that these experiments have brought out, which we believe is to be recommended, by which the heat value

found is raised by from 1 to 2 per cent. in the several calorimeters. This consists in putting on the stem of the Bunsen burner a series of disks, punctured with suitable openings to admit air, as shown in the accompanying sketch thus pre-



BAFFLE PLATES FOR CALORIMETER GAS BURNER

venting the heat loss from the bottom of the calorimeter that takes place when the calorimeter is used in the usual way with open bottom.

3. The third part of the investigation consists in a determination of the heats of combustion of some of the more

important gaseous constituents of illuminating gases in calorimeters of the Berthelot bomb type, using specially designed platinum resistance thermometers sensitive to one or two ten-thousandths of a degree, with a view to the establishment of a standard table of the heats of combustion of gases.

So far as we can forsee at the present time, our work should be far enough along to enable us to submit to your Committee a detailed report at the next annual meeting of the Gas Institute. I can assure you that the Bureau will be pleased to render your Committee every assistance that it can in your important work, and will be pleased to hear from you or the members of your Committee as to any details of the work that in their opinion requires special investigation, or the solution of which is of immediate importance to the gas industries.

Respectfully,
(Signed) E. B. Rosa,
Acting Director.

The President: Gentlemen, the discussion of this paper has been put on the program along with that of the Committee on Thermal Value and Candle-Power, and immediately following a paper on a Survey of American Gas Photometry. I will, therefore, not announce that the discussion of this paper is in order at present, but I should like to hear a motion that the committee be continued.

A motion was duly carried that the report of the committee be received and the committee be continued.

Report of the Committee on Cast Iron Pipe and Specials.

The report of this committee was read as follows by Mr. Morris:

Report of the Chairman of Committee on Cast Iron Pipe and Specials.

The Chairman of the Committee on Cast Iron Pipe and Specials begs to report as follows in regard to the work during the year.

The Committee reported last year that they had been unable to arrive at an agreement with the Cast Iron Pipe Founders, but believed by making some revisions in the standards that one acceptable to both the Founders and the Institute could be prepared. With this in view, your Committee asked for continuance.

Frequent conferences were held between members of the Committee and Mr. Lemoine, representing the United States Cast Iron Pipe & Foundry Company, during the year. At these conferences, suggestions and modifications to the standard were made and found acceptable to the Committee, and subsequent changes were made in the standard as previously prepared. Briefly the modifications are as follows:

That cast iron pipe should be as previously accepted by the Committee, that is, according to the specifications of the 1905 American Gas Light Association standard, except for the sizes 16", 20" and 24", which should be slightly changed in outside diameter so as to make the dimensions agree with those of the American Water Works Association standard Class "A" pipe and the Canadian Association, and that for pipe heavier than standard thickness, increase in weight of pipe should be obtained by reduction of internal diameter, thus retaining outside or critical dimensions and insuring correspondence in dimensions with pipe and specials.

Special Castings:

All special castings revised as to critical dimensions so as to agree with adopted pipe dimensions. Slight changes of special castings up to 12" were accepted as standard as displayed in the 1905 standard of the American Gas Light Association.

Crosses and Tees:

Crosses and tees from 16" to 48" were divided into groups as displayed in the following table so as to minimize as far as possible the number of patterns required and still provide specials of the least dimensions consistent with good design:

Sizes	Run	Branch	Spigot "S"
16x6			27″
16x8	14″	14″	28″
16x10			29″
16x12			30″
16x16	17″	17″	32″
20x6			27″
20x8	15″	15″	28″
20x10			29″
20x12			30″
20x16	19″	19″	32″
20x20			34″
24x8			28″
24x10	17″	17″	29″
24x12			30″
24x16			32″
24x20	21″	21″	34″
24x24			36″
30x8			28″
30x10	20″	20″	29″
30x12			30″
30x16			32″
30x20			34″
30x24	24″	24″	36″
30x30			39″
36x24			36″
36x30	28″	28″	39″
36x36			42″
42x16			32″
42x20	29″	29″	34″
42x24			36″
42x30			39″
42x36	32″	32″	42″
42x42			45″
48x16			32″
48x20			34″

Sizes	Run	Branch	Spigot "S"
48x24	32″	32″	36″
48x30			39″
48x36			42″
48x42	35″	35″	45″
48x48			48″

Sixteenth, Eighth and Quarter Sizes:

Sizes 4″ to 12″ as before. Practically unchanged from the 1905 standard.

Sizes 16″ to 48″ laid out for both short and long radium bands. Spigot lengths in all cases have been altered so as to provide ample caulking room.

In the quarter bends, however, the 16″ to 48″ sizes are made to agree in laying length with crosses and tees.

Eccentric Reducers, Hat Flanges, Bushings, Caps and Plugs:

Remain practically as shown in the 1905 standard. Slight changes in dimensions were made to improve the fitting where thought necessary.

Solid, Split, Hub and Service Sleeves:

These were re-designed so that castings of a given size are interchangeable as to the bottom half, so reducing the number of fittings necessary to keep in stock.

Line Drips and Side Pots:

Slight alterations in design and provision for larger variety of capacities were provided.

Generally:

Every effort has been made by the draughting forces of two companies and of the pipe founders to check the detailed weights of specials and eliminate all possibility of error, and your Committee believes the standard to represent a satisfactory and well designed line of specials and would recommend their adoption.

C. C. SIMPSON, *Chairman*,
Committee on Cast Iron Pipe Standards.

Mr. Morris: In supplementing this I wish to state that the checking up of this work and the agreement on the changes from our original standards were made after consultation between Mr. Lemoine, of the United States Standard Pipe & Foundry Company, Mr. Simpson of the Consolidated Gas Company, and Mr. Forstall of the United Gas Improvement Company. Mr. Forstall very kindly helped us in this work and is quite familiar with it, as he had done a great deal of the work on the original 1905 standard.

The President: Gentlemen, I will add to what Mr. Morris has said something that he was too modest to say. This report was submitted to the directors accompanied by large scale drawings, beautifully made of every size of pipe. The whole work showed great care and consideration. The directors after looking it over adopted it and recommended to the Institute that it be adopted. I should therefore like to hear a motion that the report of the committee be received and that the standards recommended by them be adopted.

The motion was made and seconded that the report of this committee be received and a pipe standard as recommended and reported by them be adopted by the Institute.

The President: Are there any remarks?

Mr. Walton Forstall: I would like to say a few words, not in opposition to the motion, but because I have been interested for a number of years in the subject. In 1898, the American Gas Light Association at Niagara Falls adopted a new standard, about as quickly as we were getting ready to adopt this standard and then we all went home and forgot about it. In the meantime, the founders went ahead and furnished the members with any old pattern that they had on hand. Now we have a standard which we hope we shall adopt. As soon as the Proceedings of the American Gas Institute are published, any pipe or specials that you order after that

should be as per the standard of the American Gas Institute. You will not necessarily get them, because the pipe founders will require time to prepare their patterns. You should, however, try to tie them down to a definite date, after which they will promise to give you the new standard. We were never in a better position for getting a new standard in operation quickly, because when this committee which is now reporting, tried to get certain standards adopted about a year ago, the pipe founders practically said if those standards were adopted, they would not furnish them, because they said they had patterns already made according to the 1905 American Gas Light Association standard, and that therefore it was unjust for the American Gas Institute to adopt a new standard when the 1905 standard was practically all right. As a result of this objection, the pipe founders have been consulted, have agreed to the standard now proposed, and thus have committed themselves to furnishing this standard, which is so nearly the standard of 1905 that no complaint can be made because of many changes in patterns. Therefore, it simply rests now with the members of the Institute, and they will get the new standard if they will insist upon it.

Mr. A. E. Forstall: I want to go a little farther than Mr. Walton Forstall along the same line and say that if the members of the Institute who are here present have not the full intention of using these standards, they should vote against their adoption. I think the greatest farce that was ever enacted in institute or association work was that adoption in 1898 and its immediate disregard. I felt it very keenly because I was Secretary of the Association at that time and I thought it was a disgrace to the Association. I don't think you can do the Institute any greater harm than by adopting standards and then simply ignoring them. So if you are not prepared to order and insist on getting pipes and specials according to these standards vote against them.

The President: Gentlemen, any further discussion? If

not I will put the motion. The motion is that the report of the committee be accepted and that the standards which the committee recommends be adopted. All those in favor of that motion signify the same by saying aye.

The motion was carried without a dissenting voice.

MR. DEWEY: These reports are to be taken up for discussion this afternoon. Section A will have the wrinkles that are for the manufacturing department, to discuss; Section B, distribution department wrinkles. Not all of these wrinkles will be discussed. You can read them over and if you find any particular one that you want to elaborate on or criticize, I wish you would bring it out at that discussion. There is no necessity for reading these wrinkles or the report of the bureau of information at this time. You have in your hands the report of the Wrinkle Department and of the Bureau of Information. I wish you would look them over; there are some very good things in the report, and come prepared either to discuss or criticize the same. (For report see second volume.)

THE PRESIDENT: Gentlemen, every member is expected to notice all that is contained in both of these documents, and is expected to acquaint himself with them. You have heard the report of the committee; what will you do with it? Unless there is a motion to the contrary, it will be received.

REPORT OF THE TRUSTEES OF THE GAS EDUCATIONAL FUND.

MR. A. E. FORSTALL read the report of the committee as follows:

THIRTEENTH ANNUAL REPORT OF THE TRUSTEES GAS EDUCATIONAL FUND TO THE SUBSCRIBERS TO THE FUND.

To the Subscribers to the Trustees Gas Educational Fund.

Gentlemen:—

The Trustees appointed at the Twenty-sixth annual meeting of the American Gas Light Association held October 17, 1898.

to administer the Educational Fund formed by your subscriptions, submit the following report as to the work done from October 1, 1910, to September 30, 1911.

The inquiry into the positions held by the graduates of the Class in the Section prior to that of 1909, the partial result of which was given in the Twelfth Annual Report, has been completed. The total number of graduates in the Sections named had been one hundred and twenty-seven, of whom one hundred and twenty-four were living at the time of the inquiry. Information was obtained as to the positions held in the latter part of 1910 by one hundred and three of this number.

Ninety-five of these are in the gas business and eight have gone into other lines of business. Of those still in the gas business sixty-four have obtained decided promotion, such as from the positions of clerk in the office or at the works, canvasser, storeroom keeper or draftsman, to those of superintendent of distribution, superintendent, engineer, manager or general agent of a gas company or of the gas department of a combined company.

One-half of the total number of those who have graduated from the class in the sections considered have thus obtained decided promotion. It is of course possible that these men would have obtained promotion even if they had not had the advantage of being members of the Class, but there can be no question that the knowledge obtained from the class work has been of great benefit to all of them and in the case of many, if not most, has been an important factor in qualifying them for promotion. On this point the statements volunteered by several of the men are of interest and show the benefit that these men believe they derived from membership in the class. Some of the statements taken from letters sent in reply to letters which merely asked for information as to the position held at the time by the persons addressed are given below.

"I have found the knowledge gained through this course of inestimable value to me in filling my present position

and consider the 'Catechism of Central Station Gas Engineering' a most valuable assistant to any one engaged in the gas business."

"I want to state that a good part of my advancement with the gas company was due to the information gained by the study during the time I was a member of the 1906 Class of the Trustees Gas Educational Fund."

"At the present time I am Superintendent of the Gas Company in this city. When I applied for admission to the Trustees Course I was employed as rodman by the ———— Co. Through the benefits derived from taking the course and by hard work I have reached the position as Superintendent."

"At present I am Superintendent of the ———— Gas Co., which position I have been holding for five years. The instructions I received have been of daily benefit to me since I began."

Even in the case of men who have not obtained a decided promotion the evidence given by some of them shows that their efficiency has been increased by the work done as members of the class. This holds true even for some of those who have gone out of the gas business. The two extracts from letters given below bear upon these points, the first being from a man who is occupying in the gas business only a slightly better position than he held at the time he entered the class, and the second being from a man who has gone out of the gas business into that of plumbing and steam and gas fitting.

"When I enrolled in the Practical Class I was employed as engineer in the Pintsch Gas Department and am now in charge of the gas engines in the booster department with an increase in wages, and I give all credit to my instructions in the Practical Class for my advancement. I would have done much better than this, only Natural Gas is now used in ———— and our works are practically shut down."

"I wish to say that the knowledge obtained through my course in the Practical Class was of great benefit to me not only in the Gas Business but in my present business as well."

There has continued to be a fair demand for the Catechism of Central Station Gas Engineering in the United States and during the year one hundred and ninety-four copies of this book have been sold. It is interesting to note that the majority of the purchasers are either the larger gas companies, the employes of these companies or the graduates of the Class. Comparatively few copies have been bought by the employes of the smaller companies although they might be expected to be most in need of a book of this kind. There are still two hundred and sixty-six bound copies and four hundred and fifty unbound ones available for sale. As shown by the Treasurer's Report the proceeds of the sales up to September 30th have exceeded the expenses of publication and advertising by $776.85, and this amount will be added to the surplus fund.

The Treasurer's report also shows a larger surplus of ordinary income over expenses than was the case last year. This, however, is not due as much to subscriptions from new sources as to the renewal of a number of one year subscriptions. Under the rules only one-fifth of the amount of such subscriptions is counted as applicable to the income of the year in which they are made so that their renewal has almost the same effect upon the available income as entirely new subscriptions.

During the year nineteen members of the Section of 1911 finished their course and their connection with the class ceased, while the Section of 1914 started work on January 1st, 1911, with a membership of fifty-seven.

The number of members in each section at the beginning of the year, the changes that have taken place during the year, and the names of the members of the class who have completed the course during the year, are shown in detail on the Secretary's report which is appended.

The Section of 1912 now contains sixteen members, the

Section of 1913 fourteen, and the Section of 1914 fifty-six, making the total membership in the regular class eighty-six. Two special students are receiving the questions and answers with the Section of 1914.

The card index of the principal articles published in the American Gas Light Journal, Progressive Age, and the Journal of Gas Lighting has been kept up during the year.

Very little use has been made of the room available for subscribers to the fund at the office of the secretary, No. 58 William Street, New York City. It has been thought that such a room might be a convenience to subscribers from out-of-town when they wished to arrange for meeting friends or business associates at some place other than their hotels.

The Treasurer's Report, which is appended, shows the total amount of subscriptions to date, the available income and expenses for the year, a summary of the cash account and the statement of the amount of surplus fund and the securities in which it has been invested.

The Surplus Fund, now amounting to $14,282.72, is made up of a contribution of $2,000.00, of subscriptions paid in in advance of the time when they are due, of unexpended balances and of interest received on investments. The proper portion of the advance subscriptions will, of course, be drawn out each year to meet expenses, but the unexpended balances and the interest will accumulate into a fund which will be available to assist in carrying on the work in case all the present subscriptions are not renewed when they expire.

Respectfully submitted,

Trustees Gas Educational Fund,

(Signed) WALTON CLARK,
Chairman.

(Signed) ALFRED E. FORSTALL,
Secretary.

Secretary's Report, Sept. 30th, 1911.

	Section of 1911	Section of 1912	Section of 1913	Section of 1914	Special section 1912	Special section 1913	Special section 1914	Total
Members enrolled Oct. 1, 1910...	21	20	41	0	2	1	0	85
Entered class, Jan. 1, 1911....	0	0	0	57	0	0	0	57
Additions to class since Jan. 1, 1911	0	0	0	51	0	0	2	51
Reinstated since Oct. 1, 1910....	0	1	4	0	0	0	0	5
	21	21	45	108	2	1	2	200
Resigned since Oct. 1, 1910 ...	0	0	1	4	0	0	0	5
Died since Oct. 1, 1910	0	1	0	0	0	0	0	1
Dropped for non-receipt of answers since Oct. 1, 1910........	2	4	30	48	2	1	0	87
Finished course during year ...	19	0	0	0	0	0	0	19
	21	5	31	52	2	1	0	112
	0	16	14	56	0	0	2	88

Applications on file for admission to class Jan. 1, 1912... 15

Names of Students Who Completed the Three Year's Course With Section of 1911.

Herman F. Alger, Auburn, N. Y.

George E. Beck, Philadelphia, Pa.

John J. Callahan, Stapleton, S. I., N. Y.

J. Ward Crankshaw, Philadelphia, Pa.

Joseph DeCastro, New York, N. Y.

Samuel G. Elliot, Philadelphia, Pa.
J. Lewis Goodwill, Meriden, Conn.
David S. Long, New York, N. Y.
H. P. Macintosh, 3rd, Newburyport, Mass.
A. F. Macklin, New York, N. Y.
J. A. McCulley, Omaha, Neb.
John McPhail, Jr., Detroit, Mich.
R. McPhail, Adrian, Mich.
Wm. Naile, Ardmore, Pa.
Jos. F. O'Donnell, St. Louis, Mo.
Wm. A. Root, Auburn, N. Y.
Chas. D. Slimpin, Abilene, Tex.
John J. Thomson, Coatesville, Pa.
Andrew J. Voorhees, Brooklyn, N. Y.

REPORT OF WM. R. BEAL, TREASURER, FOR THE FISCAL YEAR ENDING SEPT. 30TH, 1911.

Condition of Subscriptions.

		For year 1910–1911
Total old subscriptions holding over from second five-year period	$ 143.00	$ 112.00
Total new subscriptions for third five-year period Sept. 30th, 1910	20,455.00	3,866.00
Subscriptions received since that date...	1,041.66	208.34
	$21,639.66	$ 4,186.34
Received from subscribers since Sept. 30th, 1910	$ 4,156.66	
Payments not applicable to year	1,908.32	
Total paid in by subscribers since Sept. 30, 1910, and available for year	$ 2,248.34	
Paid in previous to current year on account of 1910-1911 subscriptions	1,936.00	

Total paid in by subscribers available for this year ....$	4,184.34	
Still to be paid for this year	2.00	
Total subscriptions available for this year		$ 4,186.34
Dues received for membership in Special Class		10.00
Total amount available for year....		$ 4,196.34

Statement of Income and Expenses.

Total amount available for year		$ 4,196.34
Expenses		
Secretary's Salary ....$	3,000.00	
Office rent	300.00	
Printing, stationery, postage, etc.......	645.18	
Periodicals and binding	18.73	
Fire insurance on books	13.03	
Total expenses for year		3,976.94
Balance		$ 219.40
Depreciation on furniture		12.64
Total balance on year's operation..		$ 206.76

Cash Account.

Received from subscribers since Sept. 30th, 1910, Current Fund ....$	4,156.66	
Interest on securities owned as scheduled under heading "Surplus Fund"...	585.00	
Interest on deposits in bank	70.49	
Dues received for membership in Special Class	10.00	
Received for copies of "Catechism of Central Station Gas Engineering," including carrying charges	1,031.53	

Total receipts for year	$ 5,853.68	
Cash balance from last year	2,490.89	
Total to account for		$ 8,344.57
Expenses for year paid	$ 3,976.94	
Expenses of publication of Catechism	103.71	
Total paid out		4,080.65
Balance		$ 4,263.92
Balance in Knickerbocker Trust Co. as per pass book	$ 1,033.84	
Balance in Guaranty Trust Co. of New York, as per statement, less checks unpaid	3,125.34	
Cash on hand	104.74	
		$ 4,263.92

Publication Account.

Total receipts to Sept. 30th, 1910	$ 2,699.55	
Received for copies of "Catechism of Central Station Gas Engineering," including carrying charges, since Sept. 30th, 1910	1,031.53	
Total receipts to date	$ 3,731.08	
Due for books delivered but not paid for	111.64	$ 3,842.72
Total expenses to Sept. 30th, 1910	$ 2,962.16	
Expenses since Sept. 30th, 1910:		
Preparing mailing list and sending out circulars in regard to Catechism	30.60	
Binding fifty copies of Catechism in leather	70.50	
Expressage, etc.	2.61	
Total expenses to date		$ 3,065.87
Balance		$ 776.85

Surplus Fund and Investment.

Amount paid in by subscribers in advance	$ 4,050.32	
Amount paid in by subscribers to Surplus Fund	2,000.00	
Net amount of unexpended balances previously reported	4,381.63	
Unexpended balance for year 1909-1910	84.75	
Interest on bonds to date	3,202.22	
Interest on deposits in bank	563.80	
		$14,282 72

Already Invested.

$2,000 Binghamton Gas Works, 1st Mtg. 5 per cent. bonds	$ 1,930.00	
$1,500 Atchison, Topeka & Sante Fe R. R. General Mortgage 4 per cent. Bonds	1,513.75	
$2.000 Omaha Gas Co. 1st Mtg. 5 per cent. Bonds	2,000.00	
$1.500 New Gas Light Co. of Janesville, 1st Mtg. 5 per cent. Bonds (guaranteed by the United Gas Improvement Co.)	1,500.00	
$5,000 Syracuse Light & Power Co. Collateral Trust Sinking Fund 5 per cent. Bonds	3,831.25	
Furniture	113.77	
		10,888.77
Balance		$3,393.95

New York, Oct. 11, 1911.

We, the undersigned members of the Finance Committee of the Trustees Gas Educational Fund, have this day examined

the books and accounts of William R. Beal, Treasurer, for the year ending September 30th, 1911, and have found the same to be correct, and the above balance of $4,263.92 to be on hand.

(Signed) ALEX. C. HUMPHREYS,
Finance Committee.

THE PRESIDENT: Gentlemen, you have heard the report. If there is no objection it will be received and filed.

REPORT OF THE COMMITTEE ON BEAL MEDAL.

DR. HUMPHREYS: In the absence of all the other members of the two committees, I report for the years 1909 and 1910. As to the year 1909, I have a telegram from the Chairman, Mr. Prichard, the other two members of the committee, Mr. Walton Clark and myself, having previously agreed.

Lynn, Mass., Oct. 16, 1911.

Donald McDonald, President American Gas Institute,
Hotel Jefferson, St. Louis, Mo.

Committee appointed to award the Beal Medal to the author of the best paper presented at the 1909 meeting beg leave to report that after careful consideration they have decided it should be awarded to Charles J. Ramsburg for his paper on Sulphur Compounds in Illuminating Gas.

(Signed) C. F. PRICHARD, *Chairman,*
Committee.

As to the year 1910, I will read the following report:

New York, October 14th, 1911.

Mr. Donald McDonald,
President American Gas Institute.

Your committee appointed to award the Beal Medal to the author of the best paper presented at the 1910 meeting of the Institute, beg leave to make the following report:

After much consideration the committee decided unanimously that the medal for 1910 should be awarded to Mr. Herbert W. Alrich, of New York, for his paper on "Brick, Concrete and Steel Holder Tanks."

Your committee experienced some difficulty in arriving at a decision, not because there were no papers presented worthy of the award, but rather because there were so many that it was difficult to select one as being better than the rest. As was remarked by one member of the committee, "There is not a young engineer in the country but who could get very great help by a careful study of all the papers read."

Respectfully submitted,

W. H. BRADLEY, *Chairman.*

Mr. Prichard in a letter to Mr. Bradley dated October 13th expresses his preference for Mr. Alrich's paper. A. C. H.

I shall take the liberty of making an additional statement, and I am inclined to think that the other two members of the committee would agree with me: that mention should be made of Mr. Lamson's admirable paper. The committee was somewhat embarrassed by the conditions under which Mr. Lamson's paper was submitted and was obliged to conclude that the conditions under which it was submitted eliminated it from the competition. By this statement I do not mean to be understood that Mr. Lamson's paper necessarily would have received the medal. It might and it might not. In referring to Mr. Lamson's paper I introduce the qualification because I do not want to detract from the credit rightfully due to Mr. Ramsburg.

THE PRESIDENT: Gentlemen, that completes the routine business. Next in order is the reading of the paper on "Costs and Results Obtained from Automobile Delivery," by Mr. L. R. Dutton.

Mr. Dutton then read his paper as follows:

COMMERCIAL MOTOR DELIVERY, COST AND RESULTS.

It was the original intention to present in this paper only the purposes for which motor delivery is being used and the cost of such service to the gas industry.

With this thought in view a series of questions were prepared on a sheet upon which replies could be made. These were mailed some months ago to about 200 companies.

The prompt, hearty response both from users and non-users indicated an unusual amount of interest. The subject is evidently one of concern to the operators of gas properties.

The replies indicated that many were satisfied with the costs obtained, many had kept no detailed costs of operation, others had used cars only a short while, and the desire was general to know what results were being obtained.

Most of the information usually found on the subject, seems to be reports submitted by manufacturers on selected cars, or accounts published of remarkable results obtained from so-called "reliability runs," of a few days duration.

The demand is for reliable information based on the operation of motor vehicles performing ordinary daily service day after day and year after year.

Very few companies had given the matter of detail costs enough consideration to prepare forms on which to keep daily or monthly records of costs of operation. Samples of record sheets which seem to meet the needs for records of horse, electric, or gasoline motor driven vehicles are shown in Figs. 1, 2, 3.

Owing to the desire expressed in many of the replies by the companies, it seems wise to broaden the scope of the paper and give some facts relative to the growth of the motor industry and its relation to modern transportation. After presenting some costs of operation of the various sizes and types of vehicles, we will discuss some of the problems involved in

DAILY TRUCK AND TEAM REPORT

NO.________ WYNCOTE, PA.____________________191__

GAS WORK	No. of Jobs	Hours	Hours	No. of Jobs	ELECTRIC WORK
IDLE					IDLE
NEW SERVICE					NEW SERVICE
EXP. STORE ROOM					EXP. STORE ROOM
AUTH. NO.					AUTH. NO.
SET AND REMOVE METERS					CONSUMER'S INSTALLATION
GAS FIXTURES					SET AND REMOVE METERS
HOUSE PIPING					MAINTENANCE MAINS
GAS APPLIANCES					HOUSE WIRING
NEW WORK FREE					FIXTURES AND APPLIANCES
GRATUITOUS WORK					MAINT. DISTR. CONDUCTORS
COMPLAINT EXPENSE					MAINT. SERVICES

ODOMETER READING FINISH.. ________

ODOMETER READING START.. ________

MILEAGE.. ________

GASOLINE USED.......GALLONS ________

OIL USED.......................PINTS ________

TIRES

R.F.	L.F.	R.H.	L.H.

WERE TIRES OR TUBES OLD OR NEW ________

REPAIRS

REMARKS

____________________DRIVER

APPROVED____________________

Fig. 1.—The form of daily report illustrated, combines the essential points of reports submitted by several companies.

AMERICAN GAS COMPANY

By the Philadelphia Suburban Gas & Electric Co. Company

Automobile, Autotruck or Motorcycle report for month of July 1911.

Make License # 622 Number 42343 Horse Power 30 Number of Cylinders 4

Number of Seats 4 Weight 2600 Size of Tires 34" X 4"

DATE	MILES RUN DAILY	GASOLINE GALS.	GASOLINE COST	OIL QTS.	OIL COST	GARAGE	TIRES	COMPANY'S REPAIRS HRS.	COMPANY'S REPAIRS COSTS	OTHER REPAIRS AND EXPENSES	TOLLS	SUNDRIES	TOTAL EXPENSES
1	87	Full		2									
2	53												
3	67	4											
4	90			1									
5	10	3											
6	20												
7	21	4											
8	25	2											
9	72	6		1									
10	31												
11	80	6											
12	17												
13	18	3											
14	52	5								Batteries			1 10
15	30	1		1									
16	40	8											
17	55												
18	41	4		1									
19	41	4								Repairs to Wind			1 10
20	20	4								Shield			
21	30												
22	50	4											
23	10												
24	56	6		1									
25	12						Repair cut						
26	14	2					3 00						3 00
27	10												
28	34	4											
29	10			1/2									
30	11	3											
31	22												
		73	693	7-1/2	94								7 87
Total	1129												13 07

No. gals. gasoline on hand first of month 10
No. gals. gasoline purchased during month 68
Total - - - - - - 78
No. gals. gasoline used during month 73
Balance on hand - - - 5

Extra tires on hand - - 1
Extra tubes on hand - - 3

Cyclometer reading first of month 185
Cyclometer reading last of month 1314
Total miles run during month 1129

Average Cost per mile - .01 2/10
Aver. No. miles per gal. gasoline 15 4/10

L. R. D.

Driver.

Approved

Supt.

It is important that an accurate record of all expenses be kept and all items entered in the proper places.

Fig. 2.—Monthly summary sheet of expenses of operating each car or motor cycle.

AUTO No. ________ CARD No. ________ DATE ________ 191..

TRANSPORTATION DEPARTMENT—ROCHESTER RAILWAY & LIGHT CO.

MFG. BY ________

PURCHASED FROM ________ DATE ________ 191__

STYLE ________ LB. ________ BODY ________

WHEELS ________ INCH, NOS. R. F. ________ L. F. ________ R. R. ________ L. R. ________

TIRES ________ INCH, NOS. R. F. ________ L. F. ________ R. R. ________ L. R. ________

BATTERY ________ CELLS ________ A. H. CAP. ________ TYPE. NO. ________

DATE PLACED	BATT. NO.	WHEEL NO.	TIRE NO.	REPAIRS			TIME OUT	MILES	K. W. H.	AMP. HRS.	DRIVER
				PART	LABOR	MATERIAL					

BATTERY No. ________ CARD NO. ________ DATE ________ 191__

TRANSPORTATION DEPARTMENT—ROCHESTER RAILWAY & LIGHT CO.

MFG. BY ________

PURCHASED FROM ________ DATE ________ 191__

TYPE ________ NO. CELLS ________ CAPACITY ________

DATE	PLACED		REPAIRS			MILES	K. W. H.	AMP. HRS.	NO. CHA'GES	REMARKS
	FROM	WHERE	PART	LABOR	MAT'L					

TIRE No. ________ CARD NO. ________ DATE ________ 191__

TRANSPORTATION DEPARTMENT—ROCHESTER RAILWAY & LIGHT CO.

MFG. BY ________

PURCHASED FROM ________ DATE ________ 191__

STYLE ________ SIZE ________ INCH

DATE	FROM		PLACED		REPAIRS			MILES	REMARKS
	WHEEL	AUTO	WHEEL	AUTO	PART	LABOR	MAT'L		

WHEEL No. ________ CARD NO. ________ DATE ________ 191__

TRANSPORTATION DEPARTMENT—ROCHESTER RAILWAY & LIGHT CO.

MFG. BY ________

PURCHASED FROM ________ DATE ________ 191__

STYLE ________ SIZE ________ INCH

DATE	FROM		PLACED		REPAIRS			MILES	REMARKS
	AUTO	POS.	AUTO	POS.	PART	LABOR	MAT'L		

Fig. 3.—Headings for daily record cards for electric vehicles and equipment, submitted by a company with a fleet of "electrics."

the adoption of motor delivery, then present some conclusions with reference to finding the truck you need.

As expressed by a recent writer on this subject, "We are living in an age of rapid advancement. Yesterday's methods and facilities prove inadequate for present day needs. Antiquated systems must go, if we in the commercial world are to keep abreast of the times and make money. Up-to-date methods of salesmanship and modern merchandising are the necessary and inseparable adjuncts of success in the present day commercial world.

In order to realize its greatest efficiency each department of any organization must be operated according to some producing standard. The time has arrived when the "up-to-date" merchant must give due consideration to commercial car service He who still hesitates to employ light delivery cars should not overlook the fact that his competitor has proven conclusively the benefits of the motor vehicle."

The advent of the motor car in the commercial world has been so gradual that few persons can remember just when they saw the first one, but the fact that pleasure car makers are hurrying into the field is convincing proof that the motor truck has proven its efficiency and economy in displacing the horse drawn vehicle.

Recent statistics of the Department of Commerce and Labor throw some interesting light on the growth of the industry, although the years shown are only from 1899 to 1909 inclusive.

In 1899 there were 57 auto manufacturers. In 1909, ten years later, there were 316, or a gain of 454 per cent. It is interesting to note the comparative increase of gasoline, electric, and steam vehicles manufactured in the last five years. These show that from 1904 to 1909

	Per cent.
Gasoline machines increased	658
Electric machines increased	163
Steam machines increased	106

If these statistics could be carried into the present year they would show a greater increase in gasoline and electric machines, but a decrease in steam.

With this increase in the manufacture and use of motor cars it is interesting to note a recent report of the Department of Agriculture, which states that in 1900 there were 15,000,000 horses in the country, while last year, ten years later, there were 24,000,000 or a little over 50 per cent. increase.

The possibilities of the future of the motor driven vehicle may be realized from the fact that there are about 7,000,000 horse drawn vehicles which could be displaced by motor vehicles of the types made to-day.

During the hot weather of July this year, figures from the health departments of several large cities show an amazing loss through the death of horses.

New York reported	1,708
Boston, Mass., reported	210
Chicago, Ill., reported	1,483
Philadelphia, Pa., reported	351
Total	3,752

This represents an investment of nearly one million dollars in only four cities.

The man with the motor truck had the best of it during the hot weather. In fact the superiority of the motor driven vehicle over the horse propelled vehicle is manifest at all times. In the heat of summer or the snow and ice of winter, the motor truck does not weary, but easily ploughs through the snow or travels the highways regardless of weather conditions.

Motor delivery gives promise of solving many of the problems involved in the present day wasteful methods of transferring merchandise on long hauls by horse-drawn vehicles.

It is worthy of note that the motor truck takes but half the space to store, as do horses and wagons to perform the same service—that the truck will carry twice the load at twice the

speed, using half the space; thus increasing the area of a densely populated city street, six times.

SPECIFICATIONS OF COMMERCIAL VEHICLES BEING MANUFACTURED, JAN, 1, 1911.

The growth of the commercial gasoline car industry can be judged from the fact that January 1, 1911, a specification chart published by one of the leading motor car journals, tabulating the cars being offered for commercial purposes, showed 220 different models being manufactured. There were 111 firms engaged in manufacturing or assembling the cars. Located in various parts of the country as follows:—

Ohio	20
New York	17
Michigan	17
Pennsylvania	11
Illinois	10
Minnesota	7
Wisconsin	7
Indiana	6
Massachusetts	5
Missouri	3
Scattering	8
	111

Of the various models being offered, the following data relates to the carrying capacity of the trucks.

Under one ton	71
One ton	36
One and one-half ton	20
Two tons	32
Three tons	29
Four tons	9
Five tons	16
Seven tons	3
Eight tons	1
Ten tons	3
	220

Some of the cars listed above are Taxi Cabs or passenger coaches, and they with the trucks average in cost, complete with body according to carrying capacity

Under one ton	$ 750.00	to	$1,200.00
One ton	1,250.00	"	1,500.00
One and one-half tons	1,500.00	"	2,000.00
Two tons	2,000.00	"	2,750.00
Three tons	3,000.00	"	3,750.00
Five tons	4,000.00	"	5,000.00
Seven to ten tons	6,000.00	"	10,000.00

Various styles of drives are listed.

Chain drive	154
Shaft drive	31
Friction drive	9
Miscellaneous drive	26

Various styles of transmission are in use.

Sliding gear	130
Planetary gear	60
Friction gear	25
Individual clutch gear	5

Cooling systems in use are:—

Water cooled	194
Air cooled	26

Two types of engine are employed.

Four cycle engine	200
Two cycle engine	20

The two cycle engines are used for all size models:—

2 cycle engine under one ton	9
2 cycle engine one ton	4
2 cycle engine one and one-half ton	2
2 cycle engine two ton	3
2 cycle engine three ton	2

With the two cycle engine the number of cylinders vary:—

1 cylinder	1
2 cylinder	10
3 cylinder	6
4 cylinder	3

Of the four cycle type engine the following is shown:—

2 cylinders, horizontal opposed	67
4 cylinders, upright	128
6 cylinders, upright	5

The speeds at which the various models may be operated seem to vary according to the carrying capacity.

Trucks of 1 ton and under, 15 to 30 miles per hour.
Trucks from 1 to 3 tons, 12 to 20 miles per hour.
Trucks from 3 to 10 tons, 8 to 15 miles per hour.

Since the above specification was prepared, the entries in a motor truck parade in Philadelphia in June, and a truck "run" in Chicago in August, show 33 new trucks not listed above, in commercial use.

SPECIFICATION OF MOTOR CYCLES BEING MANUFACTURED JANUARY 1, 1911.

Number of motor cycle manufacturers	28
Total number of models	54

1-2½ h-p. model.
1-2¾ h-p. model.
1-3 h-p. model.
1-3½ h-p. model.
24-4 h-p. model.
4-4½ h-p. model.
7-5 h-p. model.
4-6 h-p. model.
1-6½ h-p. model.
8-7 h-p. model.
2 unclassified.
9 chain drive.
39 belt drive.
4 shaft drive.
2 unclassified.
41 models equipped with free engine.
13 models not equipped with free engine.
18 models equipped with two speeds forward.

THREE WHEEL VANS.

Number of three wheeled vans manufacturers 5

Total number of models 5

1- 6 h-p. model.
1- 7 h-p. model.
1- 8 h-p. model.
1-10.4 h-p. model.
1-14 h-p. model.

5 chain drive.

5 models equipped with two speeds forward.

THE STATISTICS OBTAINED FROM 115 GAS COMPANIES IN THIRTY STATES SHOW 909 MOTOR VEHICLES IN USE AUGUST 1, 1911.

	Companies reporting		Companies reporting
Alabama	2	Missouri	1
California	2	New Jersey	5
Colorado	2	New Hampshire	1
Connecticut	4	New York	21
Delaware	2	North Dakota	1
Georgia	2	Ohio	4
Illinois	8	Pennsylvania	14
Indiana	7	Rhode Island	1
Iowa	2	Tennessee	2
Kentucky	2	Texas	3
Maine	2	Utah	1
Maryland	1	Vermont	1
Massachusetts	10	Washington	3
Michigan	6	Wisconsin	2
Minnesota	3	Total	115

LIST OF MOTOR VEHICLES REPORTED.

Motor cycles and three wheel vans	379
Gasoline motor cars and runabouts	321
Electric runabouts	11
Gasoline trucks	94
Electric trucks	104
Total	909

"Progressive Age," Sept., 1910 and Feby., 1911, published a list of gas companies using motor delivery at that time.

Illustrations of the various equipments used were included in the articles on the subject.

List of Questions Sent Out and Replies Received From About 50 Companies.

Information for Paper on "Motor Delivery."

Kind of Car, Gas or Electric and Maker?

Touring, Runabout or Truck?

Rated Load capacity?

	12 m.	20 m.	30 m.	40 m.	50 m.	60 m.
Average miles run daily	3	11	27	7	2	2

	0%	10%	15%	20%	25%	33⅓%	50%
Annual percentage depreciation gasoline ..	5	1	21	7	5	9	3

Annual percentage depreciation electric .... From 0 per cent. to 10 per cent.

	Yes	No
Do you carry fire insurance	31	4
Do you carry accident insurance	26	7
Is car driven by workmen	9	
Is car driven by experienced drivers.............	40	

	9c.	10c.	11c.	12c.	15c.	18c.
Cost per gallon gasoline your city?	3	6	7	1	6	1

	20c.	25c.	30c.	35c.	50c.
Cost per gal. lubricating oil	1	1	4	7	8

	4	5	6	8	10	12	15
Average miles per gal. gasoline ..	6	8	7	12	6	5	6

	30	40	50	80	100	150	200	500
Average miles per gal. lubricating oil.........................	1	3	1	10	8	9	6	2

Tire repairs estimated for year.

Other motor repairs estimated per year.

	0%	5%	10%	20%
Time out of service for repairs	3	11	21	2

Have you any comparative figures with horse equipments?

Have you form for keeping daily record?

Do you want this report considered confidential?
What do you consider the *strongest* and *weakest* points in Motor Delivery?

STRONG POINTS.

Long hauls possible in hot weather	8
Quick service on regular work and emergency calls	25
Does two times work of one horse	1
Cheaper and more reliable	9

WEAK POINTS.

None	3
High maintenance cost	14
Breakdowns and out commission	3
High tire costs	1
Inexperienced drivers	17

Motor Cycles.

While there were more Motor Cycles reported than other vehicles, only five companies have furnished data sufficiently complete to compile costs. These reports cover 92 two wheel machines and sixteen, three wheel vans, and will be sufficient to arrive at an average cost.

MOTOR CYCLES IN USE BY FIVE COMPANIES.

	14 machines per mile	55 machines per mile	5 machines per mile	4 machines per mile	14 machines per mile
Gasoline....	0.0016	0.003	0.004	Items	Not
Oil	0.0020	0.002	0.002	not	classi-
Tires.......	0.0012	0.001	0.002	classi-	fied
Repairs.....	0.0092	0.006	0.003	fied	
Depreciation and maintenance...	0.0091	0.022	0.016		
Total.....	0.0231c.	0.034c.	0.022	0.02½c.	0.0505
Average miles per annum	6,000 each	3,000 each	3,000 each	7,000 each	3,250 each

THREE WHEEL VANS.

	15 machines	1 machine
Gasoline	0.003	0.0020
Oil	0.002	0.0016
Tires	0.003	0.0100
Repairs	0.006	0.0120
Depreciation and maintenance	0.026	0.0140
Total	0.040	0.0396
Average miles per annum	3,000 each	2 years 12,500

The information secured from the various gas and electric companies, as well as the cost of operating seem to resolve themselves into five classifications.

First. Touring cars used by officers, managers, and heads of departments.

Second. Electric trucks for delivery and maintenance purposes.

Third. Gasoline trucks for delivery and maintenance purposes.

Fourth. Three wheel vans used by lamp inspectors and complaint men.

Fifth. Motor cycles used by superintendents of distribution, inspectors, and complaint men as follows:

Fitters emergency calls.

Fitters attention to complaints.

Paving Inspectors.

Vault Inspectors.

Inspectors of House Fitting Department.

Inspectors of Service and Main Department.

Timekeeper.

Meter Turn on and Turn Off.

Scattered meter readings.

Collectors.

Fig. 4.—Illustrating a new type three wheel van, higher h-p. than the motor cycle, and arranged for more comfort and ease for the operator.

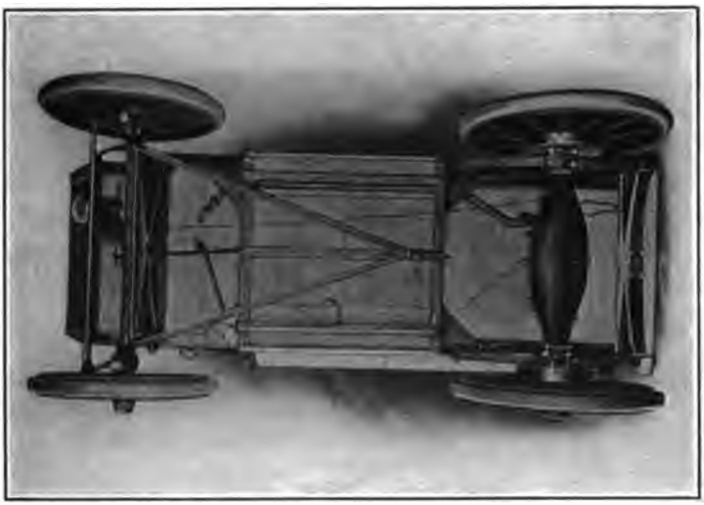


Fig. 5.—This cut of the chassis of an electric truck illustrates the power plant, differential and gears enclosed in the rear axle and rear wheels. All moving parts are dirt proof and easily accessible.

ELECTRIC TRUCKS.

One Company reporting five one ton trucks, one and one-half years old, one half ton truck, and one two ton trucks in use only a few months, furnishes the following operating costs.

The cars are all of one make.

Total mileage of the 7 cars, 39,507.

Operating expense.

Cost	Total	Per mile
Battery man	1,100.00	0.028
Battery maintenance	595.71	0.015
Chains and sprockets	146.58	0.004
Chassis repairs	54.09	0.001
Current	282.38	0.007
Generating plant	133.21	0.003
Tires	591.06	0.015
Wagon repairs	17.00	0.000
Wagon washing	587.83	0.015
Miscellaneous	387.01	0.010
	3,894.87	0.098
Insurance	539.90	0.014
Battery maintenance accrued	984.57	0.025
Tires depreciation accrued ..	199.08	0.005
Depreciation at 10 per cent. .	2,054.00	0.052
Interest at 8 per cent.	1,739.40	0.044
Total cost	9,411.82	0.238

The following figures are given on a *two* ton electric truck covering two years service.

	Total cost	Cost per mile
Current at 2½ cents per k-w...	253.88	0.0275
Labor for maintenance	486.78	0.0528
Maintenance and repairs	1,130.04	0.1225
Total expense	1,870.70	0.2028

Miles travelled, 9,225.

This truck is reported out of service for maintenance in the two years 12½ per cent. of the working hours.

The same company reports the following on a 1,000 lb. electric truck, covering a period of two and one-half years service. Total mileage 10,274 miles.

SUMMARY OF EXPENSE.

	Total cost	Cost per mile
Interest on $1,668 at 6 per cent. .	$250.20	0.0244
10 per cent. depreciation on the value of the wagon	244.20	0.0237
Maintenance and depreciation of batteries	601.02	0.0586
Tires and repairs	210.00	0.0204
Wagon expense, repairs	145.12	0.0142
Miscellaneous charges	48.54	0.0047
Total expense	1,499.08	0.1460

It will be noted that the owner of this vehicle suggests different depreciation values on various parts of an electric machine. He divides it as follows:—

First—depreciation on wagon.
Second—depreciation on tires.
Third—depreciation on batteries.

These expenses are complete, because the expense is included up to the point where the truck has a new set of tires, and is in good condition except that the wagon needs painting. It also had a new battery installed during the past year.

Valuable information on the operation of electric vehicles can be obtained by consulting the Report of the Committee on Electric Vehicles of The National Electric Light Assoc., June, 1911.

AUTO TRUCKS, ELECTRIC, COST OF OPERATING 1,500-LB. AND 3,000-LB. CAPACITY DELIVERY WAGONS, APRIL ISSUE OF "DATA."

Month	Rigs in service	Oil and supplies	General repairs	Energy kw-hr. 4 c.	Total	Maintenance Tires	Maintenance Batteries	Total miles	Av. kw-hr. per mile	Day service per wagon	Av. m's. per day per wa'n.
January, 1909 ..	1	$10.75	....	$13.68	$ 24.43	....	....	617	0.556	23.0	26.8
February " ..	2	17.96	$ 2.10	23.92	43.98	....	....	1,197	0.500	24.0	24.9
March " ..	3	15.26	....	42.28	57.54	....	....	2,329	0.454	25.5	30.6
April " ..	3	16.60	....	35.56	52.16	....	....	2,073	0.429	26.0	26.6
May " ..	3	.85	....	37.76	38.61	....	....	2,215	0.426	25.0	29.5
June " ..	3	2.00	....	37.64	39.64	....	....	2,269	0.415	26.0	29.1
July " ..	3½	39.46	....	52.92	92.38	....	....	3,136	0.422	27.7	32.3
August " ..	4½	13.90	3.21	61.48	78.59	$1.50	$74.90	3,660	0.420	25.8	31.8
September " ..	5½	.50	7.59	70.60	78.69	1.50	Cr17.06	4,175	0.423	23.5	32.4
October " ..	6	3.50	13.24	85.16	101.90	3.25	16.70	5,080	0.419	26.2	32.4
November " ..	6	49.80	28.39	85.96	164.15	207.25	39.74	5,094	0.422	24.8	34.2
December " ..	6	15.20	7.08	68.80	91.08	....	3.33	4,119	0.418	24.8	27.6
January 1910 ..	5	6.25	120.91	44.40	171.56	123.00	16.65	2,686	0.413	20.0	36.9
February " ..	6	6.90	7.38	55.20	69.48	....	....	2,816	0.489	18.5	25.4
March " ..	6	9.25	735.86	52.76	797.87	Cr 5.49	....	3,449	0.404	18.3	31.4
April " ..	6	18.40	51.50	61.96	131.86	....	....	3,964	0.410	21.7	30.5
May " ..	6	18.43	75.17	71.20	164.80	....	....	4,441	0.401	24.0	30.8
June " ..	6	22.08	103.29	81.48	206.85	64.00	....	5,099	0.399	26.0	32.7
July " ..	6	6.90	74.77	88.20	169.87	231.75	33.07	4,826	0.458	25.2	31.9
Total		$273.99	1,230.49	1,070.96	2,575.44	626.76	167.33	63,245	0.426	23.7	30.5
Av. cost per month		3.83	14.07	12.24	29.44	7.16	1.91	723	....	....	....
Av. cost per mile..		.004c	.019c	.017c	.04c	.01c	.003c	.093	....	....	....

Auto Trucks, Electric, Cost of Operating, 1,500-Lb. and 3,000-Lb. Capacity Delivery Wagons

Fixed charges and general expense	Average cost Per month	Total	Per mile cents
Drivers' salary	$ 65.00	$5,687.50	9.0
Supervision	5.22	456.75	0.7
Garage rent	5.18	453.25	0.7
Wheel tax	2.67	233.62	0.4
Washing, oiling, etc	13.00	1,137.50	1.8
Interest @ 5%, taxes @ 1.5%, and insurance @ .5% on total cost of wagon	14.58	1,275.65	2.0
Depreciation:			
Batteries, 66¾ per year on $255.00	14.17	1,239.87	2.0
Tires, 100% per yr. on $225.60	18.80	1,645.00	2.6
Balance of wagon, 10% per yr.	15.99	1,399.13	2.2
Total gen. ex. and fixed charges	$154.61	$13,528.27	21.4
Total supplies and repairs	29.44	2,575.44	4.0
Grand total expense	$184.05	$16,103.71	25.4

Operating Cost of 3-30 H-P Touring Cars of Well Known Make, Used by the Managers and Superintendents of More Companies than Any Other Make—Cost under $2,000.

	1st car 9,474 miles 2⅓ yrs. use		2d car 11,600 miles 1½ yrs. use		3d car 15,654 miles 2⅓ yrs. use	
	Total cost	Cost per mile	Total cost	Cost per mile	Total cost	Cost per mile
Gasoline	109.66	0.012	106.75	0.0092	154.60	0.010
Oil, etc.	6.28	0.001	20.85	0.0001	34.27	0.002
Tires	168.17	0.017	186.49	0.0161	243.48	0.016
Repairs	68.63	0.007	90.62	0.0078	76.43	0.005
	352.74	0.037	404.71	0.0332	508.78	0.033

RUNABOUTS USED BY SALESMEN OF A GAS COMPANY.

One gas company reports the use by salesmen of three cars costing $750.00 each. Being low priced but covering only from 500 to 800 miles per month, the depreciation was high. The amount charged for depreciation was the actual amount because the cars were sold at the end of the year, and the loss was known.

The operating expense on first car was 4-8/10 cents per mile, on the second car 10 cents per mile, and on the third car 10½ cents per mile. If these cars were used by only one salesman it would indicate that the cost was unusually high.

A well known company in another line of business having salesmen in various parts of the country furnished 14 of their men with Runabout cars costing $1,000.00 each. The cars averaged four months operation.

Average mileage of car .... 3,830 miles
Items of expense,
  Gasoline, oil and grease.
  Repairs to motor.
  Depreciation 25 per cent. per annum.
  Total cost per mile shown 14-9/10 cents.

GASOLINE TRUCKS—1,000 LBS. CAPACITY.

Cost of operating five 1,000 lb. trucks of a well known make, costing $750.00 each, with large wheels and solid tires.

	Mileage	Cost per mile
Truck No. 1	2,000	0.0926
Truck No. 2	9,210	0.042
Truck No. 3	8,160	0.045
Truck No. 4	3,565	0.045
Truck No. 5	3,924	0.045

The costs of the above trucks include gasoline, oil and grease, tire repairs and sundries. The average is very uniform, except with car No. 1, the additional expense originated from a broken motor caused by an inexperienced driver learning to

operate. The different companies operating these trucks all state that the depreciation cost is very high. In most cases the truck can only be kept in use a few months or a year and traded in for a new one. At least 50 per cent. depreciation should be charged the first year.

A practically similar experience was reported by a company with a truck of the same capacity and low cost, built by a different concern.

ONE TON TRUCKS.

Three companies report on the use of one ton trucks of different makes.

Company No. 1 reports on *two, 1 ton* trucks, total mileage 18,550 miles, cost per mile 10 cents. This includes gasoline, oil, tires, and motor repairs. The opinion of the owner is that the depreciation is 33⅓ per cent. per year.

Company No. 2, reports on *three, 1 ton* trucks. The report covers gasoline, oil, tires, and repairs. The owner estimates depreciation 15 per cent.

Truck No. 1, 6,060 miles, cost per mile 0.11 cent.

Truck No. 2, 6,300 miles, cost per mile 0.10 6/12 cent.

Truck No. 3, 8,000 miles, cost per mile 0.08 6/10 cent.

Company No. 3 reports on the operation of one 1 ton truck shown in Fig. 6.

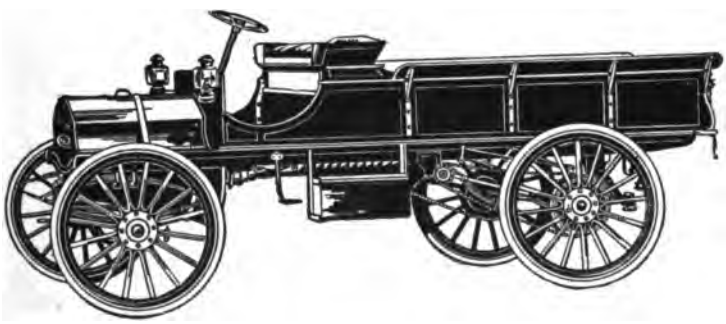


Fig. 6.—One ton truck.

The expenses on 2,600 miles operation are as follows:—

	Total cost	Cost per mile
Gasoline at 11 cents per gal.	$34.05	0.013
Oil at 50 cents per gal.	8.45	0.003
Tires (accrued)	48.00	0.018
Repairs none		
Total	90.50	0.034

The item of tires mentioned above, was owing to its being found that the rear tires were too light, they were removed and one inch heavier solid tires installed, at the above cost. The motor is of the two cycle type, the chassis being shown in Fig. 12. The air-cooling system of the engine is illustrated in Fig. 13. This car is further described by the writer in the latter part of this paper.

ONE AND ONE-HALF TON TRUCKS.

The fact that hundreds of 1½ ton trucks are in use, and that there were 50 of one make in a recent motor truck parade in which 300 cars were entered, shows that they are almost standard in that particular city.

Yet, only one company has reported on a truck of this capacity and similar make. The report covers a total of 11,160 miles and the truck was in use 14 months.

	Total cost	Cost per mile
Gasoline at 15 cents, 7 mil. per gal.	236.70	0.0212
Oil at 35 cents per gal.	35.00	0.0031
Tires and repairs	150.00	0.0134
Repairs and sundries	35.10	0.0031
Total expense	456.80	0.0408

The owner believes 12½ per cent. depreciation should be charged on this truck.

The makers of this truck have reports from the owners of hundreds of these cars and claim the operating costs to average 8 cents per mile, made up as follows:—

Five per cent. interest on investment.

Twenty-five per cent. depreciation.

Gasoline, oil, tires, motor repairs, and maintenance.

Fig. 7.—Two ton truck.

COST OF OPERATING 2 TON TRUCK.

From the reports received only three companies are using two ton trucks. Two of the companies are using the same make, and only one of the three furnish detailed costs of operation, but this report is very complete.

Truck was owned 14 months or 352 working days.

Days in use 227.

Days idle for repairs 75 or 21 per cent.

The owner reports that although this car has been on the market for several years, an unusual amount of time was lost because of poor service rendered by the manufacturer and agent, owing to delays in obtaining repair parts. When parts were received they either did not fit the machine or were not perfect.

Time lost was as follows:—

	Days
Idle due to springs	5
Idle due to tires and wheels	13
Idle due to motor	33
Idle due to transmission	15
Idle due to radiator	9
Total	75

Total mileage 11,300.
Gasoline used 2,250 gallons, = 5 miles per gallon.
Daily miles travelled 41.

A summary of the operating expense of this truck is shown as follows:—

OPERATING EXPENSE.

	Total cost	Cost per mile
Gasoline	298.23	0.0265
Oil	100.41	0.0089
Tires and repairs	432.98	0.0384
Car repair and sundries	370.22	0.0328
Labor, cleaning, etc.	514.27	0.0456
Total	1,716.11	0.1522

STANDING EXPENSE.

Insurance	68.29	0.006
Depreciation 2 per cent. per month	653.90	0.058
Total expenses	$2438.30	per mile 0.21 6/10

It should be noted in connection with this truck that a common fault was found of installing tires under capacity on the rear wheels. The wheels were also too light for the load owing to the overhang of pipe and poles from the rear of the truck. When the proper equipment was installed it was found that good service was received. The same difficulty was experienced with the springs, but they were changed to heavier type.

It would appear that this make of truck would prove very satisfactory after taking care of the usual difficulties experienced by having it properly equipped for the work to be performed. The second year's operation should prove much more economical.

EXTRACT FROM PROGRESSIVE AGE, FEB. 1, 1911.

TEN 3 TON TRUCKS.

Carefully compiled figures show that 3 ton gasoline trucks, covering 40 miles a day and operating 300 days a year can be maintained and run, at an average cost of $9.75 per day.

The items making up this charge for an establishment of ten trucks, 3 tons capacity.

Wages 10 drivers at $2.50	$25.00
Wages, repairmen, helper and washer	7.00
Gasoline, 80 gals. at 12 cents	9.60
Lubricant, 1 cent per mile	4.00
Maintenance, 10 per cent. per year	10.00
Superintendence	3.20
Incidentals, light, heat, tools, etc.	2.87
	61.67
Average running expense per truck	6.17
Interest at 6 per cent, depreciation at 20 per cent., insurance at ½ per cent., all on $3,000.	2.65
Storage, 200 sq. ft. at 50 cents per year	0.33
Add 20 per cent. for two spare machines	0.60
Total operating and maintenance cost per day	9.75
Total operating and maintenance cost per mile	0.24½

Tabulated cost of *four* 3 *ton trucks*, 4 *years old,* operating 40 miles per day in Chicago. Each truck saves $9.00 per day over horses formerly used.

Standing expense	Per day	Per mile
5 per cent. interest on $3,500.00	0.58	0.015
Insurance	0.28	0.007
Running Expense.		
Gasoline 10 gals. at $0.11	1.10	0.027
Oil and grease	0.57	0.015
Tires and general repairs	2.00	0.050
Mechanic cleaning	1.31	0.32
Total	5.84	0.14 6/10

Brewers have almost standardized one well known make of truck of 3 tons capacity; 63 brewers in 32 cities use this make ot truck.

FIVE TON TRUCKS.

Only two companies report on five ton trucks. These have both been in use a year and the exact cost has been ascertained. The trucks are manufactured by different concerns. The operating costs are shown as follows:—

FIRST 5 TON TRUCK.

Annual mileage 6,000 miles = per day 22 miles.

	Total cost	Cost per mile
Gasoline at 15 cents 0.033 mi. per gal. ..	300.00	0.05
Oil at 35 cents per gal.	105.00	0.0175
Tires	260.00	0.0434
Maintenance and repairs	87.36	0.0145
Total expense	75236	0.1254

It is interesting to note that the owner of this truck states it has depreciated only 5 per cent., and that the truck performs the same work as a horse equipment costing $14.15 per day.

SECOND 5 TON TRUCK.

Annual mileage 10,500 miles = 35 miles per day.

	Total cost	Cost per mile
Gasoline 3 mi. per gal. at 10 cents	$350.00	0.034
Oil at 55 cents per gal.	140.00	0.013
Tires	798.00	0.076
Repairs and maintenance	1400.00	0.133
Total expense	2688.00	0.256

It is interesting to note that the owner of this truck estimates 24 per cent. depreciation.

SUMMARY OF COST OF VARIOUS SIZE TRUCKS AND COST OF OPERATION REPORTED BY "DATA" IN A RECENT ISSUE.

Approximate daily cost of motor trucks	10 ton	7 ton	5 ton	3 ton	2 ton	1 ton
Chassis cost	6.000	$5,500	$5,000	3,000	$2,750	$1,500
With stake body	6,300	5,775	5,250	3,225	2,925	1,700
Average miles per day	38	46	50	60	70	80
	Per year	Per year	Per year	Per year	Per year	Per year
Depreciation 15 per cent. less cost one set tires	$780.00	$743.00	$695.00	$421.00	$390.0.	$225.00
Interest 5 per cent.	315.00	289.00	262.00	161.00	146.00	85.00
Driver $16 to $22 per week	1,144.00	1,092.00	1,040.00	936.00	936.00	832.00
Garage	300.00	300.00	300.00	240.00	240.00	240.00
Tires	1,650.00	1,231.00	930.00	620.00	480.00	300.00
Yearly overhaul and current repairs	550.00	500.00	450.00	400.00	350.00	300.00
Gasoline, at 12 cents	450.00	450.00	450.00	375.00	325.00	275.00
Oil, at 30 cents	120.00	100.00	90.00	60.00	50.00	40.00
Insurance	220.00	210.00	200.00	150.00	140.00	125.00
Cost per year	$5,529.00	4,915.00	4,417.00	3,363.00	3,057.00	2,422.00
Cost per day	18.43	16.38	14.72	11.21	10.19	8.67
Cost per mile	0.48½	0.35	0.30	0.20	0.15	0.10

The worm drive which has been adopted by builders of motor vehicles abroad is installed in this truck. Very little

Fig. 8.—Illustrating a 2 ton gasoline truck designed by a well-known gas engineer.

Fig. 9.—Illustrating the rear construction of the worm-drive truck in Fig. 8. The worms and worm wheels are shown ready to be assembled.

attention has been given to it by American builders although the housing of the worm drive in the rear construction, its

simple design, easy lubrication, and noiseless running, should favor its high efficiency and long life.

Fig. 10.—This novel motor truck has greatly increased the efficiency of the electric light cleaning force of Philadelphia. In a test run with the new truck one man cleaned and renewed the carbons in 165 lamps in six hours, quite a creditable performance. The truck can be driven either from below or from a seat on the tower, enabling one man to do the work of two.

COMPARATIVE COST OF HORSE AND MOTOR DRIVEN VEHICLE AND COST OF OPERATION.

It is difficult to present figures that will convey the advantages of the motor over the horse. The demands made upon and met by the motor are such as we could not expect of the horse. The field of transportation in the commercial world and of the Public Service Corporation, have in large cities and suburban districts expanded beyond the limits in which a horse can be considered in the solution of the delivery problem.

The question is not so much—What is the cost as *how* can I solve the problem in the most satisfactory way? *The Motor* is the only answer.

It has been proven beyond question that where the problem is purely one of delivery, with both styles of vehicle moving continuously, one 1 ton truck will cover the mileage of two one horse teams, and in hot weather three one horse teams. In some instances more is claimed. From this we can arrive at the first cost of the equipment:—

Cost of 3 horses, 2 to use 1 to spare	$750.00
2 wagons	600.00
2 sets harness	100.00
	$1,450.00

This is the same as the cost of a first-class one ton Motor Truck.

It is claimed where experiments have been made, that the comparison of mileage, load hauled, and cost are as shown by the schedule on page 30.

The same depreciation will apply to the best horse, wagon, and harness equipment as to the best motor vehicle, that is 10 per cent. to 20 per cent. per year. The average useful life of a horse being 5 to 10 years.

COMPARATIVE COST OF HAULING BY HORSES AND BY MOTOR TRUCK.

	Cost per day	No. tons carried per load	Daily average No. miles	No. miles loaded	No. ton miles	Cost per ton mile loaded one way only, in cents
One-horse wagon and driver .	$4.00	1	22	11	11	36
Two-horse wagon and driver	6.00	3	20	10	30	20
Three-horse wagon and driver	8.00	5	13	9	45	18
One-ton motor truck	8.00	1	80	40	40	20
Two-ton motor truck	10.00	2	70	35	70	14
Three-ton motor truck	12.00	3	60	30	90	13
Five-ton motor truck	15.00	5	50	25	125	12
Seven-ton motor truck	16.50	7	46	23	161	10¼
Ten-ton motor truck	18.50	10	38	19	100	9¾

Motor vehicles to perform the same work, require only one-half the number of drivers, only about one-fourth the storage room as compared with the separate spaces needed for wagons, horses, feed and hay and straw.

EXTRACT FROM THE "AMERICAN MAGAZINE," ON COMPARATIVE COST OF MOTOR AND HORSE DELIVERY.

A DEPARTMENT STORE

in Boston that adopted a system of motor truck delivery advances the following comparative analysis:

Investment account horse			Investment account motor truck		
48 horses	$250	$12,000	12-1,000 lb. machines	$2,500	$30,000
23 wagons	300	6,900	Garage equip.....		500
23 harness sets	75	1,725			
Stable equip.......		1,000			
		$21,625			$30,500

Annual Operating Expense.

Horse			Motor trucks		
Interest 6%	$21,625	$ 1,297	Interest 6%	$30,500	$ 1,830
Depreciation			Depreciation		
Horses 30% ...	12,000	3,600	Machine 20% ..	30,000	6,000
Wagons 20% ..	6,900	1,380	Garage equip. 5%	500	25
Harness 25% ..	1,725	431	Maintenance		
Stable equip. 25%	1,000	250	Machines 12x1.00x300 ..		3,600
Maintenance			Tires 12x331.20.........		3,974
Feed 48x365x44.6.......		7,814	Gasoline 12x80x300.....		2,880
Shoeing 48x365x17.2....		1,261	Garage help 4% 10x300..		3,000
Stable help 48x365x24.1...		4,222			
		$20,255			$21,309
Labor			Labor		
Drivers 23x2x300	$13,800		Drivers 12x2x300	$7,200	
Boys 22x5x52...	5,720	19,520	Boys 12x5x52 ...	3,120	10,320
		$39,775			$31,629
Stable	$ 1,620		Saving.................		33,551
Express........	23,785	25,405			
		$65,180			$65,180

Comparative Analysis.

Furniture Delivery Service.

Investment Account.

Horse			Motor trucks	
14 wagons	$250	$3,500	3 1-ton trucks at $2,400 ...	$7,200
4 wagons (single)	265	1,060	Garage equip..............	150
2 wagons (double) ...	300	600		
4 harness (single)	75	300		
2 harness (double) ...	125	250		
		$5,710		$7,350

Annual Operating Expense.

Interest 6%	$5,710	$ 343
Depreciation		
Horses 30%	3,500	1,050
Wagons 20%	1,660	332
Harness 25%	550	138
Stable equip.		
Maintenance		
Feed 14x365x44.6		$ 2,279
Shoeing 14x365x7.2		368
Stable help 14x365x24.1		1,232
		$5,742
Labor		
Drivers 4x2x300	$2,400	
Drivers 2x14x52	1,456	
Boys 6x8x52	2,496	6,352
		$12,094
Express		1,209
		$13,303

Interest 6%	$7,200	$ 432.00
Depreciation		
Machines 20%	7,200	1,440.00
Garage equip. 5%	150	7.00
Maintenance		
Machines 3 at $1x300		900.00
Tires		1,963.80
Gasoline 3x90c.x300		810.00
Garage help 2 at $5x300		1,500.00
		$7,052.80
Labor		
Drivers 3x14x52	$2,184	
Boys 3x8x52	1,248	3,432.00
		$10,484.80
Saving		2,818.20
		13,303.00

Recapitulation

Investment account

Machines	$37,850.00
Horse	27,335.00
Increase	$10.515.00

Annual expense account

Horse	$78,483.00
Machine	42,113.80
Saving	$36,369.20

Total machine invest	$37,850.00	
Total horse invest	27,335.00	
Total additional invest	10,515.00	Refunded in 3 months and 14 days by annual saving of $36,369.20
Total machine invest	$37,850.00	Refunded in 12 months and 15 days by annual saving of $36,369.20.

And in addition the following advantages:

Abolition of expressage within a radius of approximately 40 miles.

In outlying districts delivery direct to address and not to local station or store.

Increased business in outlying districts.

Abolition of stable.

After the expiration of 12 months and 3 days this installation will have paid for itself, and with the reduction of $2,271 interest on investment previously charged, will earn for the organization $34,098.20 annually, and maintain itself permanently and in prime condition.

LIMITING THE SPEED TO INSURE LONG LIFE.

To guard against excessive speeds two methods have been devised. One is more effective than the other.

The speed scale of a well known "Speed Indicator," Fig. 11 makes it possible for the truck to be driven at a speed consistent with safety.

When the maximum speed is reached the driver is confronted with the danger signal, "*Slow Down,*" in big red letters, easily read at a distance.

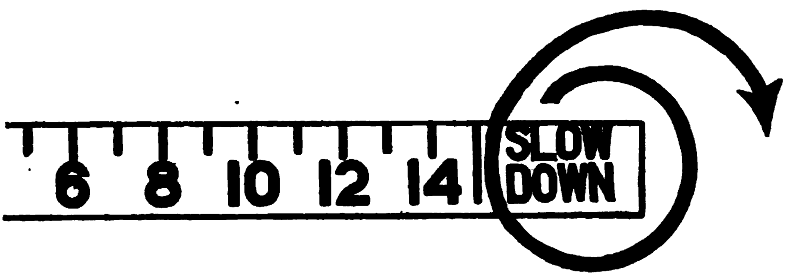


Fig. 11.

Another and more effective check on speed is a "Governor" now applied to motors by many makers. This checks the flow of gasoline to the carburettor, when the proper speed limit is reached.

Even with these devices the judgment of a driver cannot be spared, since a six mile pace on broken, rutty pavements can do more damage to a laden car than twice the speed on a smooth asphalt street. The right kind of driver "nurses" his truck over rough places, ruts, and raised car tracks.

Running at 12 miles per hour quadruples the shock of a six mile pace, since two times the ground is covered, and every obstruction is struck with double force.

THE MAN AT THE WHEEL.

Right handling of the truck on the road is a matter of knowledge and honesty on the part of the driver. It is safe to say that three in every four cases of trouble which afflict motor-wagons are due to neglect or failure to realize, on the part of owner and operator, that a power truck is not a combination locomotive and flat car. On the contrary, it is a machine, a compact, complex, special machine which bears the same relation to ordinary shop equipment as a fine watch does to an alarm clock.

To bring the strength of thirty or fifty horses within the compass of a man's stretched arm, and hitch this amazing power to a five or seven-ton platform without sacrificing handiness, requires the nicest balance of strength, size and weight in design and at least intelligent care in operation and upkeep. The business man who would not trust a slide-valve steam engine—the simplest of prime movers—to any but a qualified engineer will expect both economy and efficiency from a motor truck in the hands of a teamster whose training at the best covers two weeks or a month in the builder's local garage or drivers' school, and no longer than two or three days of instruction and demonstration on the road.

OVERLOADING AND EXCESSIVE SPEED ARE THE CHIEF DANGERS.

Commercial cars get no sympathy from their drivers. Because they are machines, too often they are "cracked through" as long as they will stand the strain and blamed during the remaining period of their existence. Because they do not balk or lie down, do not lose flesh or show wear and tear for some time after deterioration begins, owners who are reasonable in every other department of their business, overload them fifty per cent., drive them at excessive speeds and make no provision for their proper inspection, cleaning and oiling. The care given a motor vehicle on the road and in the garage, has so much to do with its working efficiency and cost, that owners would do well to study its limitations as well as its possibilities.

TIRE MAINTENANCE.

Owing to the important part claimed by tires in the operation of motor vehicles, the writer believes prominent attention should be given the subject by users.

A schedule of sizes of tires and weights they are to carry here listed, is considered almost standard among tire manufacturers.

AIR PRESSURE FOR INFLATING PNEUMATIC TIRES AND CARRYING CAPACITY PER WHEEL OF STANDARD SIZED TIRES.

Diameter of tire inches	Maximum weight on wheels, pounds	Air pressure in tire, pounds per square inch
2½	225	50
3	350	50
3½	600	60
4	750	70
4½	1,000	80
5	1,000	90

CARRYING CAPACITY PER WHEEL OF STANDARD SIZED SOLID TIRES.

Diameter of tire inches	Maximum weight per wheel pounds	Total weight truck and load
2″	500	2,000
2½″	750	3,000
3″	950	3,800
3½″	1,375	5,500
4″	1,750	7,000
5″	2,000	8,000
6″	3,000	12,000
7″	4,000	16,000

CARE OF PNEUMATIC TIRES.

The care of tires can be only touched upon here. Fortunately for owners the competition among tire manufacturers makes it possible to get good results and satisfactory treatment by consulting them. In cases of serious tire trouble they will be glad to suggest remedies that will lengthen the life of the tire.

In general, besides overloading and speeding, the chief causes of tire depreciation are contact with oil, flying starts and abrupt stops, unequal brake pressure, fast running in street car tracks, and the usual failure to adapt the pace of the car to the condition of the street or roadway.

A representative of a leading tire manufacturer offers the following suggestions:—"There isn't a tire maker in the world who can turn out tires that will stand up under the usage some drivers give them. We will always have trouble from reckless drivers. Fifty per cent. of all pneumatic tires that go to pieces do so not because they are worn out, but because they receive careless handling. Every time a driver applies his brakes with violent force causing his wheels to scrape along the roadway, he inflicts an injury to the tread that cannot help but materially reduce the mileage he should get out of the tires. The same applies to faulty starting of the car.

The grinding effect exerted on the tires when running in street car tracks, or scraping along the edge of a curb in stopping is also sure to lessen the strength and wearing qualities of the tire. Driving around corners at a high enough rate of speed to cause the wheels to skid is also a fruitful source of wear. The speed at which a car should be driven is a question every motorist has to settle for himself. His pocket-book is usually the reckoning basis. High speed produces high cost of tire maintenance. There is no dodging the fact. Speeding and tire economy have absolutely nothing in common."

Some tire makers with the education of the motorist in view —and the increased sale of their goods, guarantee tires under certain conditions, for a limited mileage, for a specified length of time.

With each tire sold they issue a certificate which induces the purchaser to become familiar with the chief causes of tire depreciation.

A prominent place in the certificate is given to the fact that the tire is guaranteed for blank miles against "blow outs," rim cutting, and blistering, but the tire must be properly inflated

at all times, in accordance with the schedule of air pressure referred to in this paper.

Another condition which governs the guarantee is that in case of puncture or other trouble which may cause deflation, the tire must not be ridden upon. Rim cutting is sure to result.

Damage occasioned by misuse, abuse, neglect, or by contact with any obstruction in the road is not covered by the guarantee, and such damage should be repaired when noticed. Under the schedule of mileage allowance given on the certificate, the tire is presumed to have furnished an average of 25 miles per day. Where these conditions have been adhered to, there has usually resulted good service from the tire.

CARE OF SOLID TIRES.

In the matter of depreciation of solid tires, we believe tire makers are also working to establish some basis of guarantee. In one instance, a well known tire is guaranteed for blank miles usage within six months from the date of its purchase, irrespective of the conditions under which it is used.

The recent report of the committee on "Electric Vehicles" read before the "National Electric Light Association" in New York City, report as follows on tires as applied to electric vehicles.

"Your committee has taken up the question of efficiency of tires on pleasure vehicles, and would report that there is a difference of from 30 per cent. to 70 per cent. between the heavy gasoline type of tire regularly sold and the best special electric tire on the market. This difference in tire efficiency means that, with the best tire as against the heavy gasoline tire, nearly double the mileage and double the life of the battery is obtained, if the vehicle is given proper attention."

PERCENTAGE OF TIME OUT OF SERVICE.

Referring to the replies, "Percentage of time out of service for repairs," it will be noted with pleasure that experience has shown the average to be not over 10 per cent. and we believe it is safe to assume that at least 5 per cent. of this time

was consumed in the annual examination, cleaning, and repainting of the car, and the other 5 per cent. would be divided between repairs to the motor and repairs of tires.

It is doubtless true, that there are many cases where a car or truck has been purchased and placed in use in a city where repair parts are not to be had, and time must be consumed in awaiting the arrival of parts from the factory. With the increase of motor delivery this will become more apparent—that the matter is being given serious consideration, will be noted from the following Editorial upon

UNIT CONSTRUCTION.

The Editor of the "*Commercial Car Journal*" in a recent issue states with reference to the solution of continuous commercial car delivery:

"The pleasure car owner thinks nothing of laying off his machine for a week or even ten days, awaiting a part, but if this same thing happens to a commercial car user, there is immediately a "Time" with the agent or the manufacturer of the machine because this inactive truck is in all probability causing a loss to the owner of anywhere from $10.00 to $20.00 per day, while the pleasure car owner was simply inconvenienced.

It is generally conceded that something must be done in the car field which will positively do away with expensive delays occasioned by the necessity for renewing vital parts of the mechanism. It is true that careful daily inspection and up-to-date service department and relief methods make it possible to keep a well built machine almost continually on the job. Yet in spite of these precautions, expensive and annoying delays will occasionally take place.

It is very gradually dawning upon designers that the removable unit system is a sure cure for all these ailments. Some designers actually believe they are using removable units in the cars of their construction. The question arises what constitutes a removable unit? Is an engine which is bolted and lock-nut and cotter pin retained in the frame a removable unit?

Certainly it is not in the sense in which we use the term. Under such a definition almost any part of a vehicle might be termed a removable unit.

By "removable" we do not simply mean that in half an hour or an hour a crew of men with a machine equipment back of them can remove the offending part, leaving an aching void in which nothing will fit. Such a removable part has no place in rapid car transportation. To be really removable the part should be so arranged that strapped, winged-nut and cam fastened binding or holding parts are all that are required to firmly anchor the removable portion in place. The alignment and the positional relation of the part to the rest of the mechanism should be automatically cared for by the mere act of tightening the strap, wing-nut or cam binder."

The writer then refers to European practice and road conditions, and tells of the future emergency wagon with a complete equipment of parts which it will carry and concludes with this statement. "It may seem to some that these are rather radical statements, but there is very little doubt but that these rapid renewal possibilities must be perfected, before the best can be hoped for from a commercial car installation.

STANDARDIZATION IN CONSTRUCTION.

In this connection it may be of interest to note that the Society of Automobile Engineers now has a membership of about 800 of the ablest engineers and experts having to do with the automobile industry, and within the past year, has accomplished results which will be found to have made history of a definite nature. Those who have used motor cars or trucks are only too well aware of the fact that there has been apparently no attempt at standardization of any of the small parts which go into the construction, aside from tires and other accessories, and will all welcome results that will be attained by this society.

There will be no attempt by the society to throttle original research as to changes in engines, changes in transmissions, or any portion of an automobile. This does not alter the fact,

however, that it is better to have a novel engine or novel transmission made up of component parts which are standard and well tried out, than one which is not only novel in design but one in which every element is novel and untried.

The society stands ready to assist in manufacturing difficulties and necessities in any of the many engineering fields of automobile production. As an example, the manufacturers of electric lighting systems for automobiles, recently applied to the society to take up the matter of standardizing certain features of the lighting system, and this matter was promptly taken care of.

FIRE AND ACCIDENT INSURANCE.

There seems to be no question as to the advisability of carrying insurance. The replies are largely in favor of doing so. Irrespective of whether insurance is carried or not, we believe it good policy to carry a small portable hand fire extinguisher on the gasoline machine, where it is easily accessible in case of emergency. Dangerous fires may originate from leakage of gasoline in the piping system, or "back-firing" in the carburettor. We believe the majority of such fires could be readily extinguished if small extinguishers were carried with the trucks.

The report of the Committee on Electric Vehicles mentioned elsewhere refers to the fact that "liability insurance companies are beginning to realize the difference between a gasoline car and an electric, as far as liability insurance is concerned. The commercial gas car can run and often does run twice as fast as the electric. The gasoline pleasure car frequently makes from 45 to 60 miles an hour, while the maximum speed of the pleasure electric car is between 20 and 25 miles. The electric is under perfect control and its freedom from extra levers, intermediate gears, etc., makes it so simple of operation that in case of emergency, the operator does not become confused as to which operation to perform.

Because of the lower speed when collisions occur, the impact is less severe and the damage consequently slight. The

heart of the machine, the motor in the electric, is under the car and out of harm's way, while the engine in the gas car is in front and subjected to serious damage when a collision occurs. Absence of inflammable fluid in the electric makes a fire practically impossible. The Fire Insurance Companies recognize this latter feature and allow electric trucks on wharves, docks, in sheds and warehouses, where the gas truck is prohibited.

The freedom from fire in a garage which is strictly electric as compared with the gasoline garage is almost self-evident, and the fire insurance companies are beginning to make a rate accordingly. The electric vehicle is no more hazardous from the fire standpoint than a horse and wagon, in fact, probably less so, for, with the electric vehicle, there is no inflammable hay stored to feed the flames when once started."

DEPRECIATION.

(Gasoline Vehicles)

When you keep a motor in first-class repair all the time, replacing worn parts as they show, what reason is there for charging a high annual depreciation? This question is raised in some of the reports received,—while others state, at least 33⅓ per cent. of the cost should be charged off annually on gasoline cars. Opinions appear to vary, but the majority consider 15 per cent. to be the proper figure. This does not include tires which are generally conceded should be listed under running expense.

Depreciation may be considered in different ways. That is, many trucks as constructed to-day, will be obsolete within two years and if used but slightly, would not sell for 50 per cent. of their original cost within a year.

Is *depreciation* on a well built truck not largely a matter of operating expense, and should it not be charged off according to mileage?

For instance, the reports show 30 miles per day to be the average distance travelled, which amounts to about 9,000 miles per year. It is generally conceded that the well built vehi-

cles are good for seven years or about 60,000 miles. As an actual fact, many trucks are in use to-day that have covered double this mileage and are still in good condition.

Fifteen per cent. for 9,000 miles = 1⅔ per cent. nearly 2 per cent. 1,000 miles. Using 2 per cent. for a basis, the following schedule may apply:—

	Value	Depr. cost per mile
Under 1 ton trucks	$1,000.00	0.01½
1 ton trucks	1,250.00	0.02
2 ton trucks	2,400.00	0.04
3 ton trucks	3,000.00	0.05
5 ton trucks	4,000.00	0.06⅔
10 ton trucks	6,000.00	0.10

Many companies reported 15 per cent. first year, 25 per cent. second year, and 30 per cent. for the third year as a basis; others reported 15 per cent. annually, reducing the annual remaining value each year. This would not prove satisfactory. As an example, 15 per cent. per year on the original cost would depreciate the total in six years and eight months while in the latter plan suggested, at the end of the same period one-third of the original value would still remain.

DEPRECIATION ELECTRIC VEHICLES.

Referring to the reports, the indications are that opinions again vary, but not so widely. Some companies prefer to charge enough on the maintenance to cover this item. Others vary the amount under tires, battery and wagon body. The smaller number of exposed wearing parts and the lower speed at which they are operated, are large factors in favor of the longer life of an electric vehicle. See Fig. 5.

It is interesting to notice in connection with electric vehicles that although the depreciation is low and the operation costs seem satisfactory, that three-fourths of the electric trucks reported were those from combination gas and electric companies.

It is assumed that the determining factors in the selection of

electric trucks by them, may have been from the fact that they had a competent man to place in control of the charging and attention to batteries and that they were selected because of the advertising value attending their use. Their intention may also be to popularize their adoption by present users of other delivery equipments and increase the sale of electric current.

FINDING THE TRUCK YOU NEED.

It is evident from the reports received, that the Managers of many companies are seriously considering the introduction of motor service at an early date.

Before purchasing, a number of significant facts should be taken into consideration, since choosing the right truck is the beginning of economy in motor delivery. When you purchase the power wagon it is not enough to assure yourself that the design is good, the construction honest, the makers responsible, and the experience of other users such as to guarantee your own success in operating it. It is better to pay more to the Manufacturer than to the garage repair man. Do not buy a truck because it is low priced. You need to make sure also, that the truck is the type and size best adapted to the kind of service you require. The only way to accomplish this is to analyze your hauling problem, *know* what you want and pick the truck which has made good under similar conditions in actual use.

It is apparent that the experience which has been unsatisfactory, has been due to the fact that the Gas companies have either selected trucks which were unsuited to their requirements or else have remodelled second hand touring cars by simply substituting commercial bodies for delivery purposes. No changes have been made in the size of tires, or the gear ratio, to reduce the speed at which the truck may be operated. In many cases, the springs have not been strengthened for the different service required of them, nor shock-absorbers or supplementary springs installed to meet the new conditions. Owing to this, many light delivery trucks have proven unsatisfactory.

Motor trucks are not yet either perfect or fool proof machines. But there are many good ones and the types, designs, and capacities are so varied that the man who knows what he wants can find the right truck to save him money and improve his service. Several years' experience, observation, and experiment are behind the conclusions here offered in the selection of light delivery gasoline trucks.

SIZE OF WHEELS AND TIRES.

The size of wheels, for example, bears directly on the cost of tires, the most important single item in the upkeep of a power wagon. Most of the wheels are too small. They should be at least 38 inches. With larger wheels, a longer section of the tire engages the pavement, the load per cubic inch of rubber is less, traction would be better and friction less. The larger wheels would also have the effect of smoothing out defective pavements.

SPRINGS.

To be thoroughly serviceable a spring should possess two essential qualities in due proportion, good resistance and resilience. That is, a spring should move from its idle point very quickly and should be so constructed that under unusual stress and strain heavier and stronger proportions of the springs would be brought into play.

With a horse drawn vehicle we have only to provide against a maximum roughness of the road with a minimum speed. Railroad trains have only to contend against a maximum speed over a minimum road roughness. When we come to the motor vehicle, we have to provide both for a maximum speed and maximum road roughness.

The springs of trucks of two or more tons capacity are generally satisfactory, but in the light delivery wagons more attention should be given to this subject. The writer believes in flexible springs with proper supplementary springs or shock absorbers. With this equipment the vehicle will be found satisfactory under varying loads.

Fig. 12.—Chassis of 1 ton truck, 2 cycle motor.

ROAD CLEARANCE.

Be careful to purchase a truck with at least 15 inch road clearance. In winter during heavy snow falls a good power truck will go anywhere with a load that it will go in summer, if the axles and under-body will clear the top of the drifts. If not, the truck becomes a snow plow.

ENGINE CONSTRUCTION.

After four years experience with power vehicles equipped with two cycle engines the results obtained have been more than satisfactory. The few wearing parts of the motor have made the repair bills very low. The motor is unit construction, and in two types of cars used, is installed in front under

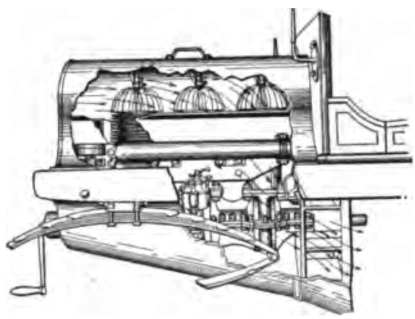


Fig. 13.—System of air cooling, 2 cycle motor.

the hood, where it it is readily accessible. The chassis of the truck, shown in Fig. 12 illustrates this more fully.

AIR COOLED.

The motor is air-cooled, the air being drawn through the front of the hood by a suction fan which is integral with the fly-wheel at the rear of the engine, as shown in Fig. 13. The hood is so constructed that the air reaches all the cylinders uniformly. None of the trouble has been experienced which is possible with a water-cooled system with radiator; in the varying weather conditions of winter, there is no water to freeze.

IGNITION.

The ignition system is very simple. There is an entire absence of wires and coils under the body of the car; the magneto is direct connected to the crank shaft in front of the engine, the wires are extended direct from the magneto to the spark plugs.

LUBRICATION.

The lubrication system is very simple, the proper proportion of lubricating oil being mixed with the gasoline in the main tank and fed to the engine through the carburettor. This obviates the difficulties arising with the usual oiling systems. The bearings of the engine are fitted with individual oil cups.

TRANSMISSION.

The transmission is of planetary type and is readily adjusted in a few minutes. A motor vehicle of this type seems to eliminate nearly all the causes of trouble originating in the construction of the ordinary light motor vehicle, and it is surprising that many companies are slow in adopting it. In fact, only three gas companies report the use of a vehicle of this type, but they agree that the cost of operation and depreciation of the car is lower than most other gasoline motors of the four cycle type. Recently in examining a two cycle engine which had been in operation four years, and travelled 18,000 miles, the interior of the cylinders were found as perfect as when new.

Many Department Stores and Motor Service Companies, requiring a fleet of several cars, have adopted this two cycle motor form of truck and hundreds in use have shown a low cost of operation and depreciation with inexperienced drivers.

SUPERVISION OF DRIVER.

The average driver needs some supervision. The writer believes it wise, if four or more trucks are in use, to employ a mechanic to have direct supervision over the trucks and make adjustments and repairs daily as are necessary. He will be able to keep the motors at the top-notch of efficiency, keep

them in service nearly every day in the month, add years to their life, and save a good part of his wages on supplies and repairs and eliminate the necessity of an annual overhauling.

The average driver will handle his truck more carefully, if he has a daily check system on his operations; he will waste less oil and gasoline if he is reporting on forms illustrated in Figs. 1, 2 or 3. The reason is that this report focuses the driver's attention on the chief factors which count in his day's work.

If not enough trucks are owned to maintain a mechanic, it would be a good investment to pay a competent driver extra, for making daily after-hour inspections of the trucks in service. Paying drivers for overtime work is cheaper than securing an out-side expert, and it concentrates his attention more upon the responsibility of keeping the truck in service. His thoughts are directed to the wearing parts, and you are almost certain to get better results.

APPRECIATION.

The writer desires to express his appreciation of the service rendered by those who have assisted in the preparation of this paper. Editors and publishers of auto journals have given advice and information. Manufacturers have loaned electrotypes and specifications of cars. Members of the Institute and others have been generous in their coöperation by furnishing all the information they had. In some instances this entailed much labor and care in its preparation.

It is the hope of the writer, that the paper submitted will be of aid to some fellow gas man and in the words of a leading Auto Advertiser, help him "Make two minutes grow, where only one grew before."

THE PRESIDENT: There are doubtless members here who know something on the subject or ought to be anxious to find out. I will not call on anyone in particular, but I should like to hear a full discussion of this paper.

MR. WALTON FORSTALL: I have been very much interested in motor traction for three or four years. Two years

ago, it was forced upon our attention because we were obliged either to build a horse stable or a garage. What we actually did was to build a temporary horse stable that we could convert into a garage. We operate in Philadelphia through six different districts, and one district we converted from horse to electric wagons. We have now been running in that district about two years, and we are very well satisfied indeed with the service. We are not absolutely certain just what our saving is as compared with horses, because that bug-a-boo of the depreciation question cannot be settled until we have had the wagons in use for a much longer period than two years. We are actually figuring on a ten per cent. depreciation. We are using this figure until we find out whether it is either too little or too much, but it seems safe to say at present that we ought to operate with the electrics for at least seventy-five per cent.—perhaps a little bit less—of our horse cost. We recently changed over another one of our districts, so that now in Philadelphia we have about $60,000.00 invested in electric vehicles, which shows that we have some faith in this service. To give you some idea of what it means in a city the size of Philadelphia, in our Distribution Department we have 105 horses; 57 meter wagons, of which 8 are electric; 2 meter vans, horse-driven, to carry our meters from our main Meter House to our district shops; 16 main and service wagons, which are general delivery wagons for main and service material, of the open express type, of which 4 are electric; 5 lamp wagons, which carry around incandescent material, arc lamps and lights, one of them is electric; we have 18 pipe trucks which are horse-driven; 16 stove wagons, which carry stoves and stove connecting material—one of those is electric; 6 hauling wagons, 2 dump wagons; 5 drip wagons; 2 leak wagons; one paving wagon; 3 carts; 295 bicycles; 49 motor cycles; and 25 motor cycle vans. Our ultimate hope is to have all of our wagons power-driven. Whether they will be all electric or all gasoline, or part electric and part gasoline, is uncertain, but I rather think it will be most electric and part gasoline, because we have a certain service where the

mileage is probably beyond that economically possible with an electric wagon.

I have made a few notes on Mr. Dutton's paper. He speaks of the motor truck taking half the storage space of a horse wagon. We now have a stable with a capacity for 80 horses. In a few years, we may be forced out of a neighboring district shop. In that case, our present plan is to turn the stable into a garage for electric wagons. This would enable us to use for the district shop the entire second floor of the stable.

On page 72 is shown "time out of service for repairs." We bought certain extra parts, such as wheels and chains, and, in our two years of electric service in a district looking after 60,000 meters on a quite exacting schedule, there has never been a time when we had to call on horses for aid. The electrics have always been on the job.

The electrics are also very largely independent of inexperienced drivers. We took the drivers that we had on the horse wagons—I do not think we raised their wages. It took them but a short time to learn how to run the wagon, and we have had no accidents.

Mr. Dutton speaks of motor cycles and also motor cycle vans. Our experience with vans has been very much that of learners. We bought the best there was on the market. We charged fifty per cent. depreciation against them, and I don't believe that was quite high enough.

There are two makers of motor cycle vans that I know of, who are now getting out what promises to be a much better type than we have had, a better model. One of them is shown on page 75, and one model has not come out of the factory yet. I saw it there about a month ago. I don't know what the model on page 75 costs, but I rather think it costs a little more than a new type of runabout that is on the market. We bought one of the latter. If we can buy a four-wheel runabout, on the back of which we can put a box which will contain a lot of incandescent material (for the

conveyance of which we use these motor cycle vans), for anything like the price of a three-wheel van, we would prefer the runabout. We would expect to get more work out of the runabout, and if it proves satisfactory, we would never go back to the three-wheel van, unless indeed the price becomes much cheaper than the runabout. I think the four-wheel runabout costs $350.00, and that we paid about $260.00 for the three-wheel vans.

I was interested in the worm-drive shown on page 88. Some months ago we ordered a 2,000-pound electric wagon, expecting to get a worm-drive, but just at that time the makers decided to abandon the use of a worm-drive for that size of wagon, confining it only to wagons of less capacity. In view of this fact, and also that the worm-drive has been given up by the company having the longest experience in the building of electric wagons, I am awaiting with quite a little interest to see whether this form of transmission is satisfactory with a gasoline wagon.

On page 102, Mr. Dutton speaks about the difference in the treatment of depreciation. The situation as I see it, is as a rule, that you are using horses and want your people to buy motor wagons, and they want to know what it is going to cost. Until we know more about depreciation, it seems to me that ten per cent. is the least you can charge against an electric wagon, and twenty per cent. against a gasoline wagon. Of course, as soon as you are sure that any arbitrary charge of depreciation is larger than required, you should at once get the figure down to what experience seems to indicate as proper.

Mr. Dutton says it is generally conceded that a well built vehicle is good for seven years, or about 60,000 miles. The trouble so far has been to discover the *well built* vehicle. Our experience with pleasure vehicles has certainly been that the same make varied from year to year. When we find a well built vehicle, we expect to stick to it.

About deciding on the wagon you need. That is a very important point. You should be very careful before you buy,

to be sure you are getting a large enough wagon. In every case you will find that where power succeeds horse traction, you will be able to carry heavier loads. We started out with a 2,000-pound wagon for both our meter and service work. We at once found that our 2,000-pound service wagons were being sent out with more than 4,000 pounds load, and that any smaller load would not be economical. Of course, such overloading of the 2,000-pound wagon would in time seriously affect both its springs and its tires. Fortunately, our business grew quickly, requiring additional wagons, so we were able to change our 2,000-pound service wagons into meter wagons and buy 4,000 pound wagons for our service work. We have found for two years that 2,000-pound for meter work and 4,000-pound for service work is ideal for our conditions.

Mr. R. M. Searle: I want to say, as an automobile manufacturer, that we have a paper here that all the automobile engineers in the country and all the automobile manufacturers have never been able to get from the industry. It takes the American Gas Institute to produce a gas man to show the automobile man how to get up a series of articles and the series of statistics honestly compiled to make possible the needed style of truck. It is unique and nevertheless mortifying to me as a manufacturer of automobiles. In Rochester we had the problem confronting us of a steadily increasing cost of horse distribution. It became necessary to consider a system of outlying shops. The superintendent made a study of the matter and put different colored pins in a map showing the various types of distribution, new meters, stations, plants, etc., and those colored pins illustrated that we had reached the saturation point in certain characteristics of our demand inside the two-mile circle, and that ninety per cent. of all our work was being done outside of the two-mile circle. For outside of the two-mile circle it became necessary to have automobile delivery. One of the most interesting economies that it has affected is the transportation of the Italian laborers. The men who work in that section can get out to their work

in these big trucks and are thereby physically able to do a full day's work and return at night in the truck. After transporting them the truck continues in use for the rest of the day. The transportation department has doubled the economy of our truck service. The economy problem in automobile study brings in the personal equation. We have one man who at one time made it his business to keep tabs on all the trucks in Rochester and he reported at least fifty chauffeurs. The result was that we cut the cost of maintaining the trucks almost in half. This system of espionage in the early education of the truck usage has shown the chauffeurs that they can get better treatment for better care of their trucks, and I was surprised to see the Chauffeurs' Club the other day pass a resolution to that effect, showing how much better they could handle their employers' vehicles and how much better they could succeed if they handled them honestly and would be governed according to the automobile dealers' advice. We started in with sixty horses. We take in this analysis the characteristics of high load. We now have sixteen horses, four of them being sold, and thirty-four vehicles doing the work. The problem confronting us in Rochester at first and which handicapped us considerably was the question of winter delivery, the question of snow. When the snow came in Rochester heretofore sleighs went out, the horse carriages and wagons were abandoned; snow was heaped up in great piles and ruts were formed by the sleighs. Today there are so many electric vehicles and so many gas vehicles that as soon as the snow falls these vehicles pack the snow. Last winter, in one of the biggest snows that we have had, these automobiles had no trouble in going to any part of the city, the snow being packed hard, and that overcame a great difficulty that we have heretofore had with our vehicles.

I want to mention the question of overload. On page 88 he says: "Illustrating a two-ton gasoline truck designed by a well-known gas engineer." On page 83 is shown a two-ton truck designed by an automobile engineer. One is a worm-

driven automobile of two tons with ninety-nine per cent. of the load on two back axles; the other, by the automobile engineer, would have eighty-four per cent. distributed between the two axles. The efficiency of the two-ton truck on page 83 in maintenance will be about a quarter of that on page 88, both in the tire expense and the wear and tear on the engine. It simply shows the necessity of one man camping on a design and perfecting a type that fills the bill. Take the question of electric trucks for maintenance with the new iron-clad battery, the cost of maintaining an electric truck is about half for battery and current consumption over past experience. You want to make a study of the electric vehicle for ordinary work from two points, one, from that of its absolute reliability. We will guarantee with an electric truck out of three hundred working days, two hundred and ninety working days. We will only guarantee two hundred and twenty-five with a gasoline truck. Another point about the electric, to many of us here using generators, we can get current at night at as low a cost as it is possible to produce it, because the charging of the average electric lighting and average gas works distribution department will be included, if you are generating current for your purpose, which makes it very economical.

Mr. Forstall brought up a most valuable point on the number of working days you can keep a car in use by having duplicate parts. Two duplicate wheels and two duplicate springs will increase a car in the average man's hands from about 180 days—that is one-half of the working time—to an assured 225 to 230 days out of a possible 300.

The question of overloading a vehicle is a most serious one, if you put an automobile in the average man's hands.

I have noticed as soon as men go to a race and see a driver make a mile in thirty or forty seconds, or when two or three hundred automobile people leave the fair grounds to go home, everyone is a racing maniac—they all want to go home in forty seconds. That same thing obtains each time a pleasure car passes a horse on the road, I will defy any man to pass

a horse on the road that the farmer does not take the whip out and whip up the horse. With that same human instinct he wants to go faster. A man goes to the freight depot and sees a two-ton load. He has a one-ton truck and says he can make that in one load, but that is probably the last trip that he will make for awhile. If he had made it in two trips, the car might go on working for quite a number of useful days with big economy. The Rochester Carting Company has in use two electric trucks of the general vehicle type built in 1900, and still in service in first-class condition, having been kept in perfect repair. Those trucks averaged about thirty miles a day. It shows a good long life for an electric truck.

I want to mention the question of depreciation. The true amount of depreciation in trucks would be what the trucks would bring if you are going to sell out twenty trucks and put in twenty new ones to take their places. You say, I am figuring on getting rid of A because I like B better; it will pay me better to put in a new type with a longer life and efficiency and speed. That is the true mark of depreciation. The author is quite right, if the truck keeps in first-class condition and at the end of ten years you have none of the original truck left, still the truck has had no depreciation—paradoxical as it may seem. After you have four trucks, you can afford to maintain a competent mechanic, who can devote enough time to keep the trucks in first-class condition.

The next thing is the education of the driver and paying him good wages. The driver is earning theoretically about three times what your horse driver used to earn. Another secret of getting capacity out of the gas truck or electric truck is the crew that are to load and unload it. We have talked about the cost per mile. That is not the thing but the cost per ton mile is what you can figure on as they do in the railroads, and if you have men on either end in motor equipment to load and unload rapidly, the cost per ton mile can be cut in half.

THE PRESIDENT: Is there any other member who would

like to be heard on this subject? It is a very important and very interesting one. We have about ten minutes left before the hour of adjournment.

Mr. Norris: There are two or three things I would like to bring out. One is the importance of the design being such as to admit of easy repair. One phase of this, which is brought out by this paper, is in regard to interchangeability. I happen to know of two cars of the same make, of two different years. One cost $14.50, the other cost $2.75 for labor for the same repair.

The man who is developing a car for low operating cost must keep this in mind, and design it so that the parts can be readily changed when they are worn out.

Another thing is the importance of sleeving all working parts. Take the spring shackles and the eyes in the springs. These ought to have removable sleeves so that when they wear, you can just knock the old sleeve out and put in a new one and a new bolt, and that part of the car will be just as good as it was originally.

In regard to the cost of maintaining cars, we have outside of Philadelphia between fifteen and twenty cars used by superintendents. The average maintenance cost, exclusive of depreciation, is somewhere between seven and eight cents, including in a few cases garage charges, there being one or two cars that are not kept at the gas works. It includes cars ranging in original price from $900.00 to $4000.00.

Now in regard to overloading trucks, would it not be practicable to use the springs of a car as a sort of platform scales? Some sort of a movable, adjustable scale could be mounted on the rear axle that would indicate approximately the load on the car. A glance at this scale at any time would show approximately the load on the car. From time to time this scale could be checked and re-set to offset any set to the springs. Something of this sort would give the operator of the car some guide as to what load is going on, without his having to figure it up.

With regard to the question of governors, I believe that the governor on a motor truck is going to be an essential part of its equipment, and I think that the governor should be so designed that it will operate on the engine and not on the car; that is, it should be so designed that the governor will prevent the engine attaining a higher speed when on the intermediate and low gears than it will on the direct drives. That means that when you are on the intermediate gear or on the low gear, the car will have to be driven at a lower speed. When a driver goes into the intermediate speed on a hill, the tendency is for him to try to make the car go up the hill just as fast as when on the level on the direct drive. This means racing the engine and a general racking of the car.

THE PRESIDENT: Gentlemen, the Chair would on his own motion request the Technical Committee for next year to carry this question farther. It is a very live one and it is changing all the time, but it seems evident that it is only a matter of a few years when all of our horses will be displaced by automobiles, and we ought to develop a machine especially suitable for our own purposes.

MR. NORRIS: The question of 2-cycle vs. 4-cycle motors is a rather controversial one, but my personal experience indicates that a 2-cycle engine properly designed is a thoroughly efficient, practical commercial motor, and it has almost none of the disadvantages that its opponents claim. It has some other small disadvantages but they are not serious.

THE PRESIDENT: Mr. Dutton has the floor to close the discussion if he wishes to do so.

MR. DUTTON: There are two or three points, Mr. President, that I think might be emphasized. The first one is in reference to your appointment of a committee to carry on work of this nature. I assure you it was very difficult to get any uniform information for compiling the costs this year. Reports received from the companies showed a great lack of uniformity in the keeping of different costs. In some cases the depreciation cost would be shown and then

a part of the operating costs, while in other cases only a portion of the operating costs were submitted.

I believe the committee would be wise in submitting to the companies a form of report through which they might classify their expense in a uniform manner.

Referring to Mr. Searle's remarks in reference to the two (2) ton trucks mentioned, I thoroughly agree with him in regard to the design of truck shown on page 88, that it probably will develop a weakness in having placed the rear wheels under the center of the body as shown. In this connection I want to do justice also to the designer of that truck and state that it is an error in rating it as a two-ton truck since the truck was originally designed as a 1½-ton truck only.

The point should be noted in comparing these two trucks that absolutely no trouble has arisen from the use of the truck shown on page 88, while there has been trouble in the rear construction of the truck shown on page 83. Referring to the remarks in the paper, "It should be noted in connection with this truck that a common fault was found in installing tires under capacity on the rear wheels. The wheels were also too light for the load owing to the over-hang of pipe carried in the rear of the truck." This brings up the question of overload. It is important to find out where your over-load is. In this particular case the difficulty probably was not in the truck when used in regular service. It probably would be all right for everything except when it was used with a heavy load overhanging the rear. We would particularly emphasize the importance of having the truck designed for the proper kind of service to which it is to be devoted.

The questions to which Mr. Norris has directed our attention, those of uniformity of design and standardization of parts, are very important. This matter is referred to under the heading "Standardization." Since this paper was prepared I understand the Standardization Committee of Automobile Engineers have standardized on the electric lighting equipments now being placed on many 1912 model touring

cars and also during the past few weeks, they have selected a standard for the iron flanges, size of bolts, number of bolt holes, etc., to be used on the rims for solid tires for commercial trucks. Tires being one of the main points of weakness and expense, I think this is going to be of decided advantage to us this coming year.

THE PRESIDENT: Gentlemen, I take the authority of presenting to Mr. Dutton the very hearty thanks of the Institute for his paper. I am sure we all appreciate it.

After announcements were made by the President, in regard to tickets for the banquet, a photograph of the members to be taken immediately after the adjournment of this session, and arrangements for return trips, and in regard to the double sessions of the afternoon, and the reading of a letter by the Secretary received from the National Commercial Gas Association, the meeting adjourned. (At 12:40 P. M.)

AFTERNOON SESSION.

(Section A)

The meeting was called to order by the President at 2:30 P. M. The President announced that the first business on the program would be the reading of a paper on, "Some Principles of Condensation with Especial Reference to Water Gas," by L. E. Worthing.

Mr. Worthing read his paper as follows:

SOME PRINCIPLES OF CONDENSATION WITH ESPECIAL REFERENCE TO WATER GAS.

Any attempt to gather from the technical journals, data with reference to condensation, impresses one at once with the extreme paucity of information concerning water gas condensation, and the comparative abundance of literature (for it can scarcely be called data, for very good reasons) on the condensation of coal gas. We cannot fail to be equally impressed with the widely conflicting theories of condensation there set

forth, even where the practice is substantially the same. Although, generally speaking, the advocates of slow condensation have had the upper hand in recent years, yet we are left in doubt as to whether it is most desirable to effect a uniform, slow condensation, or a condensation rapid in parts and slow in other parts. Shall we carry the tar fog some distance along the condensing system, thereby bringing it to an equilibrium of tension with the naphthalene in the gas and sacrificing the candle-power, or shall we remove the tar fog at once, mechanically, by a P & A or one of Dr. Coleman's cyclone separators?[1] Shall we, with Mr. Barthold,[2] expose our gas in the hydraulic main to the solvent action of the tar, or shall we, with some German engineers, actually spray our gas with tar at the outlet of the hydraulic main? Shall we go still further with Professor White of the University of Michigan, who, in a paper which will have been made public before this is read, has given us the results of a series of experiments in the course of which gas was actually washed with tar of various consistencies and at different temperatures, or shall we abandon slow condensation altogether, with M. St. Clair Deville,[3] who has given up the attempt to retain the benzol which will dissolve in the tar if the latter is allowed to come to an equilibrium of tension with regard to the benzol in the gas, in order to rid himself of the naphthalene which will also be dissolved in the tar, under those circumstances?

M. St. Clair Deville has undertaken a series of tests at the experimental plant of the Paris Gas Company at La Villette. He regards it as axiomatic that the primary object of condensation is to get rid of naphthalene. As abstracted in M. Laurain's paper, read before the last meeting of the Société Technique du Gaz, his method is simply to pass the gas and tar fog upwards through a refrigerating chamber, or tubular condenser, through which the water flows in the same direction as the gas. This condenser is so adjusted in area, velocity

[1] *Gas World*, June 11, 1904.
[2] *American Gas Light Journal*, June 1, 1900.
[3] *Journal of Gas Lighting*, May 30, 1911.

of gas, rate of flow of water, etc., that the gas and tar fog are chilled from 150° F. to 60° F. It is, moreover, fitted with baffle plates in the lower third of the vessel so as to further retard the fall of the tar and bring it into more complete equilibrium with the gas. The flow of the water is so regulated that the outlet temperature is only 8 or 9° F. above that of the inlet, and the short foul main slopes down to the inlet of the condenser, so that any tar condensed there cools in contact with the gas. After leaving the refrigerator, the tar fog is removed by an impact condenser. M. Deville regards cold tar as a better absorbent of naphthalene than hot tar, and by this method utilizes the whole of the tar in the gas to absorb the naphthalene, and that in the best possible state for the rapid attainment of equilibrium with the gas, viz., in the state of tar fog. He admits the loss of a certain amount of benzol, but claims it to be only 5 per cent. of the total, and negligible in view of the other benefits obtained.

Although this system is at present in successful operation at the works at Le Londy, representing a production of 12,750,000 cu. ft. per twenty-four hours, yet there was no lack of dissenting voices among the members of the Societé. Among these was M. Grebel, who quoted a loss of benzol from three to six times as great, at the works at Gennevilliers after the discontinuance of the hot condensers.

All these systems of coal gas condensation are conditioned by the necessity for the removal of naphthalene. Water gas condensation, however, faces no such limitations.

Thrusting aside the naphthalene question, the object of condensation is to retain in the gas the desirable elements while ridding it of the undesirable. We desire to retain a maximum candle-power and heating value: in other words, the greatest possible quantity of benzol and other light oil vapors, at the same time freeing it from tar fog and heavy oils.

The process of condensation is governed by the laws of vapor tension, Dalton's and Regnault's laws. The application of these laws to modern gas engineering practice was very clearly demonstrated by Mr. Earnshaw in his paper written for

the third annual meeting of this Institute, on the subject of Benzol Enrichment.

As far as one aspect of condensation is concerned, that of retaining in the gas the maximum amount of benzol vapors originally present, the principles enunciated in Mr. Earnshaw's paper are precisely the principles by which we must be guided.

Water gas leaves the superheater at a temperature of from 1,250° to 1,450° F. As this is cooled, those components of lowest vapor tension will condense out of the gas, leaving the gas more or less saturated with those components (benzol, etc.) of higher vapor tension. But these high tension vapors, or liquids, are miscible in all proportions with the liquids (tars and heavy oils) already condensed, having low vapor tensions.

Consequently, Regnault's second law—*i.e.*, when two liquids are miscible in all proportions, the vapor tension of the mixed liquid is intermediate between the tensions of the separate liquids—comes into operation.

Now, if the operation of this law is allowed to continue till the system—gas—benzol, etc.—condensate—is in equilibrium, the effect will be that some of the high tension vapors (benzol, etc.) will be absorbed by the liquids of low vapor tensions (condensate) and the average vapor tensions of the gas and condensate, with respect to benzol, will be the same. Consequently, the candle-power of the gas will be appreciably diminished.

If the system comes to partial equilibrium, the condensate—or liquids of low vapor tension—will absorb some of the benzol, etc., having high vapor tensions. The amount of benzol, etc., absorbed, and hence, the decrease in candle-power, will depend altogether on the degree of equilibrium which the system —gas—benzol—condensate—has attained.

This degree of equilibrium depends on three factors:

(1) Time of contact of condensate and gas.

(2) State of division of condensate.

(3) Temperature of gas and condensate.

Over the second of these factors we have little control.

Concerning the first, it is obvious that the longer the time

of contact between the gas and condensate, the greater the opportunity for them to come into equilibrium of tension with respect to benzol.

Concerning the third, it is equally obvious that the lower the temperature which the system—gas—benzol—condensate—is allowed to attain, the higher will be the percentage of benzol absorbed by the condensate from the gas. In other words, in order to rid ourselves of the tar and heavy oils, we are taking from the gas some of those valuable constituents which we wished to retain.

It is necessary to cool the gas in the condensing system to the lowest temperature it will meet in the mains, otherwise we are simply increasing the length of our condensing line and will get condensate out of the drips. When the gas is cooled to this necessary temperature, the condensate contained in it is in the best possible condition to absorb benzol, because it is in a state of extremely fine division, offers a large absorbing surface, and can thus come rapidly to a condition of equilibrium with the gas. This tar fog is only slowly removed from the gas by friction along the sides of the mains, in the relief holder, in the tubular condensers, and finally by the P & A.

Obviously then, by any system which admits of a state of equilibrium of tension between the gas and condensate, we are losing a part of the valuable high tension vapors; and it is equally obvious that any form of slow condensation presents a very favorable condition for such an equilibrium, both on account of the comparatively long time contact between the gas and condensate, and the extremely fine state of division of the condensate, in the form of tar fog.

A logical system of condensation would be one that afforded as short a time of contact as possible between the gas and condensate, or rather, the complete removal of that condensate as soon as formed.

As the gas begins to cool rapidly on leaving the superheater, and as we can reasonably assume that the tar fog when first formed is in the state of extremely minute particles, thus offering a maximum absorbing surface, and as its specific capacity

for absorbing benzol becomes progressively greater as the temperature is lowered, it will be advisable to install the condensing system as close as possible to the machines. It is certain that mere cooling will not rapidly remove the condensate from contact with the gas. Some mechanical method must be adopted. The impact separator has not been successful unless the whole system of gas and condensate has been reduced to a temperature where the absorptive capacity of the condensate for benzol is very great, thus resulting in a serious loss of candle-power. A system which satisfies to a very considerable extent the conditions imposed on us by a consideration of the laws of vapor tension is that offered by the Doherty Washer Cooler.

Briefly, this is a device in which an ascending current of gas, traveling at a relatively low velocity, meets a descending current of water sprayed into the chamber by any suitable means. The water spray serves at once to reduce the temperature of the gas in the most efficient manner, and to wash out and carry away mechanically the resulting products of condensation. By this means the condensate produced by a given lowering of temperature is carried away at once, before it has had time to come into equilibrium of tension with the gas.

This system affords the further advantage of a fractional condensation, as condensate falling from the top falls through progressively hotter and hotter temperature zones, thus decreasing its capacity for absorbing benzol and forcing it to give up any benzol absorbed, more than that normally absorbed at the inlet temperature of the gas.

It is a question, however, and one extremely difficult to determine, as to whether the condensate in the apparatus ever absorbs enough benzol to be in equilibrium of tension with the gas even at the inlet temperature.

The solution of this question, like that of many others attendant on condensation, is conditioned by the difficulty of getting a fair sample of unpurified gas, and this difficulty makes all conclusions drawn from experimental data extremely hazardous and uncertain. Most of the data, therefore, con-

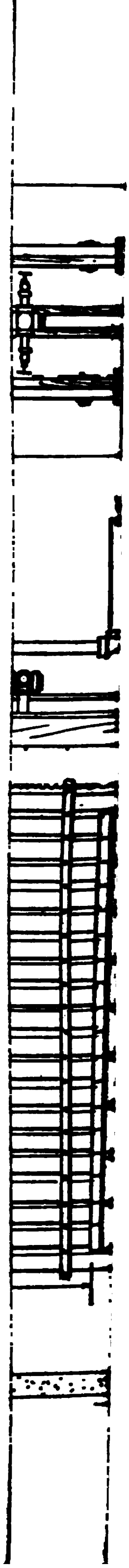
cerning the installation that I am about to describe is taken from actual works tests, and the experimental observations, though conducted with every possible precaution, are offered for exactly what they are worth.

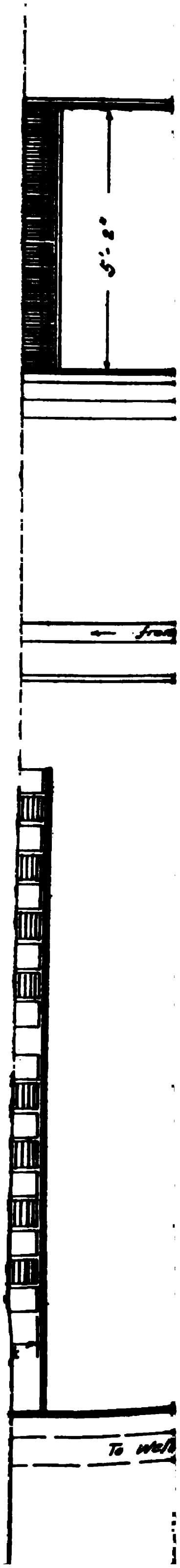
The washer cooler we are about to describe was installed at one of the plants of the Detroit City Gas Company in August, 1910. An old condenser shell, which had formerly been used for coal gas, was utilized for the apparatus. The shell was 33 ft. long, 14 ft. 10 in. high, and 5 ft. 2 in. deep. It was divided into three washing compartments by suitable baffle plates so arranged that the gas passed always up against a descending water spray. (See sketch.)

These compartments have been numbered 1, 2, and 3 on the sketch and in the data, the first compartment being next to the outlet gas, numbering having reference to the circulation of the water, instead of that of the gas. Each compartment was filled with twenty courses of wooden grids composed of ½ in. by 6 in. strips set edgewise, separated by ¾ in. spaces. The strips in each course of grids were set at right angles to those in the courses above and below, so as to provide the most effective washing arrangement.

The courses of grids were supported on two sets of three I beams strung across each compartment. The circulating water entered a 4 in. header running above the shell with cocks for each compartment. Three 2 in. pipes across the top of the shell distributed the water into eighteen sprays centered 16 in. by 18 in. These sprays consisted of inch nipples passing 6 in. below the top of the shell, ending in a slotted cap, the slot being ⅛ in. wide and about 1 in. long, looking down at a 45° angle. These caps were so arranged that the spray covered the whole surface of the grids. There was a 15 in. space between the caps and the upper course of grids.

The liquor circulation, beginning at the well, was as follows: suction line from the well to No. 1 pump, which forced the liquor through a cooler, consisting of two stacks of twenty 2½ in. pipes connected by cast iron return bends, each stack being made up of twenty foot lengths. The cooling water was

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supplied by the works pump and was distributed over the pipes by wooden troughs carefully leveled so that a stream of water of uniform thickness overflowed from one side of each trough. (See sketch.)

The liquor passed from the cooling coil into the sprays of the first section, down the grids to the base, from there through a suction line to No. 2 pump which forced it into the sprays of the second section, thence to No. 3 pump and third section, and from there overflowed through a 8 in. sealed overflow into a 10 in. line to the well. (See sketch.)

The well served as a liquor reservoir and separator basin for the tar, which was pumped daily into a small well alongside, from which it flowed by gravity to storage.

The pumps, which were of the Roots rotary type, were geared to a 5 h-p. 3-phase Allis-Chalmers motor. Actual working tests showed each pump to deliver 125 gallons per minute. They were so connected that No. 1 and 2 or No. 2 and 3 were interchangeable. One, two, or three pumps and one, two, or three sections of the washer cooler could be used at will. For further details, see drawing.

The washer cooler has been in operation for more than a year and has given most satisfactory results. The capacity is exceedingly great, and in fact can hardly be estimated—being limited only by the amount of heat to be extracted from the maximum quantity of water we can put through the washer cooler without raising the back pressure excessively—and the ability of the cooling coils to reduce that water to a normal initial temperature. It has taken care of a make of over 300,000 feet per hour without difficulty, so long as we could obtain sufficiently cold water for the cooling coils.

The water required is only 1/13 of that necessary for the old form of tubular condenser, thus relieving the works pump of a very considerable load. The ground space, assuming it to replace scrubbers for four machines, is only ¼ of that necessary for the scrubbers.

As soon as the washer cooler was put into operation, we were enabled to by-pass the P & A and the Chollar washer.

The P & A has not been in use since, and the Chollar washer only during heavy loads in hot weather, when the capacity of the cooling coils was not sufficient to reduce the water to the necessary initial temperature. A second cooling coil is now being installed, and will be amply sufficient to take care of any condition likely to arise in the works. The elimination of the P & A and Chollar washer brought to light another advantage of the washer cooler—the exceedingly low differential through it. Below is a table of differential pressures through the washer cooler for different arrangements of pumps and sections. It will be noticed that the maximum differential pressure is 1.6 inches.

Comparing that with the ordinary 15 in. differential through the P & A and Chollar washer, we can calculate a saving of

DIFFERENTIAL PRESSURES THROUGH WASHER COOLER WITH ONE, TWO AND THREE STAGES AND ONE, TWO, AND THREE PUMPS, GAS PASSING AT THE RATE OF 150,000 CU. FT. PER HOUR.

Inlet	Outlet	Differential	Pumps	Stages
3.2	1.8	1.4	No. 1 & 3	2 & 3
3.2	1.8	1.4	"	"
2.4	0.9	1.5	"	"
2.6	1.2	1.4	"	"
2.6	1.2	1.4	"	"
3.1	1.8	1.3	"	1, 2, & 3
3.0	1.6	1.4	"	"
3.0	1.6	1.4	"	"
2.5	1.0	1.5	No. 1, 2, & 3	"
2.6	1.1	1.5	"	"
2.7	1.2	1.6	"	"
3.0	1.6	1.4	No. 1	"
2.7	1.3	1.4	"	"
2.6	1.1	1.5	"	2 & 3
2.6	1.2	1.4	"	"
2.3	0.8	1.5	"	3 (one stage)
2.2	0.6	1.6	"	"
2.2	0.6	1.6	"	"

7 h-p. per hour; and balancing against this the 2 h-p. per-hour necessary to operate the circulating pumps, we have a net saving of 5 h-p. per hour. The tar and heavy oils are totally removed at considerably higher temperatures than in ordinary operation.

This results in more effective purification, ease of revivification, and longer life of material. The percentage of oil and tar present in the purifying material is less than 1/6 the percentage present under the old method of operation. The material comes out of the boxes loose instead of in sticky cakes, and revivifies with most remarkable rapidity and thoroughness.

WATER GAS CANDLE-POWER AND B. T. U. FROM 12:50 A. M. TO 4:25 A. M. 2-18-11 AND FROM 12:30 A. M. TO 3:00 A. M. 2-22-11.

Gas as made			Gas after 96 hours' exposure		
Time	C-p.	B. t. u.	Time	C-p.	B. t. u.
12:50	23.73	683.7	12:30	22.27	664.2
1:15	23.83	684.4	12:50	22.43	671.5
1:25	23.75	595.3	1:10	22.57	672.2
1:45	23.99	684.4	1:30	22.55	671.5
2:05	23.51	683.2	1:50	22.50	673.6
2:25	23.78	682.3	2:10	22.40	671.5
2:45	23.99	682.3	2:30	22.42	670.4
3:05	23.76	673.5	2:50	22.47	671.5
3:25	23.33	675.9			
3:45	23.40	670.0			
4:05	23.12	666.6			
4:25	22.88				
Average	23.60	680.1		22.45	670.9

Loss in candle-power: 1.15
Loss in B. t. u. 9.20

That this system of condensation does not tend to produce a tender gas, has been thoroughly demonstrated by actual

operation records since it was installed, under very severe weather conditions. A test of this point was made last winter. A rather high candle-power water gas was made at Station A, and pumped into an enclosed holder, the holder having been flushed previous to filling. After standing in the holder twenty-four hours, the gas was pumped through a main (over three miles long) to an open holder—lines and holder being also flushed—and allowed to stand for 72 hours, after which it was pumped back to Station A. Candle-power and B. t. u. tests were made at twenty minute intervals as nearly as possible, when the gas was pumped into the enclosed holder at Station A, and similar tests were made when it was pumped back to Station A from the open holder at Chene St. The gas in the holders was subjected to a minimum temperature of 12° F. and an average temperature of 26° F. A record of the tests is found in the appended table:

ATMOSPHERIC TEMPERATURES TO WHICH GAS WAS EXPOSED DURING 96 HOURS.

Date	Minimum	Maximum	Average
2-18-11	26	37	33
2-19-11	26	30	28
2-20-11	20	24	22
2-21-11	12	22	17
2-22-11	28	34	30

These results show that this gas, which under ordinary condensing conditions, could not fail to be extremely tender, showed a drop of 1.15 candles and 9.2 B. t. u.'s, which speaks for itself.

A determination of the amount of benzol absorbed by the condensate in the washer cooler is attended by considerable difficulties, owing to the extremely uncertain samples of unpurified gas obtained. In arriving at the results in the appended table, large sample tubes were inserted in the main at the inlet and outlet of the washer cooler, these tubes being capped and having openings looking in the same direction as the stream of gas. These openings were respectively in the

center, midway between the center and circumference, and at the periphery of the main. The sample tubes were bushed down to ¼ in. in the main and the gas stream was led through trains of flasks set in a freezing mixture, thence through a tar filter of glass wool, to the meter. As the apparatus was on the inlet side of the exhauster, the gas stream was pulled through the train with an air aspirator. All connections were ¼ in. glass tubing, and every precaution was taken to prevent tar washing of the gas.

Condensate from these tests was taken, separated from the water, carefully fractionated, and the amount and specific gravity of the benzol determined. The results are given below, and show a comparatively slight loss of benzol (and hence, of candle-power) in the washer cooler.

GRAMS OF BENZOL PER CU. FT. OF GAS AT INLET AND OUTLET OF WASHER COOLER. BENZOL FRACTION TO 81° C. REDISTILLED.

No.	Cu. ft. of gas	Inlet temp.	Outlet temp.	Gram. benzol per cu. ft.	Sp. gr. Gas at 15° C
A. Inlet	220	160	49	0.149	0.874
Outlet	264	120	47	0.137	0.880
B. Inlet	324	154	48	0.143	0.876
Outlet	280	126	48	0.136	0.878
C. Inlet	262	165	51	0.153	0.872
Outlet	196	132	50	0.156	0.874
D. Inlet	149	144	47	0.162	0.875
Outlet	184	115	48	0.144	0.883
E. Inlet	265	154	50	0.151	0.875
Outlet	200	123	48	0.142	0.882
F. Inlet	125	142	48	0.147	0.872
Outlet	160	118	49	0.140	0.876
G Inlet	255	160	51	0.154	0.876
Outlet	220	125	49	0.143	0.881

Determination of benzol absorbed by condensate as determined by distillation of tar: Tar per M. cu. ft. gas separated

in W. C. equals 0.096 gals, = 0.80 lbs., = 363 grams tar per M cu. ft. of gas. Percentage of benzol in tar is 1.3 per cent.; grams of benzol per cu. ft. of gas lost in W. C. = $0.363 \times 0.013 = 0.005$.

What is probably a more trustworthy indication of the work done by the washer cooler can be obtained from the works results. These showed a saving during the twelve months succeeding the installation of the washer cooler over the two years previous of 0.254 gallons of oil per M, a consummation distinctly satisfactory.

I do not wish to be considered as holding a brief for the washer cooler. It can only be regarded as one method by which the principles laid down at the beginning of this paper can be successfully applied to water gas condensation.

The basic ideas that a consideration of the laws of vapor tension force upon us are:

First, that slow condensation, in which tar fog formed is carried along with the gas at a diminishing temperature, is ruinous to candle-power, owing to the tendency of the tar fog to come rapidly to equilibrium with the gas at these reduced temperatures, when its specific capacity for absorbing benzol is much greater than at the temperature at which it was formed.

Second, that, disregarding the naphthalene question, as we can generally afford to do in water gas practice, a successful system of condensation must be one which will remove the tar fog or condensate at comparatively high temperatures, as soon as formed, so that it will not have an opportunity to get into equilibrium with the gas, with respect to benzol, at that final temperature at which the gas must enter the mains.

There is no reason why this system cannot be applied to coal gas manufacture, always providing that the outlet temperature of the gas from the condensers is at least as low as any temperature it will afterwards encounter. If, after we have removed the tar at a comparatively high temperature,

the gas is further washed and cooled, the effect will be that only a small amount of comparatively heavy oils will be removed, together with the naphthalene in excess of that necessary to saturate the gas at the outlet temperature. Candle-power will not be affected, because there is not enough benzol in the gas to saturate it, even at the minimum temperature, and the amount of condensate extracted after the removal of the tar is so small in volume that it will have practically no effect in absorbing benzol according to the tension-equilibrium laws. There will be just that amount of naphthalene in the gas necessary to saturate it at the outlet temperature of the gas. Now, if the gas is not further cooled, there will be no deposition of naphthalene in the mains.

We can readily see that outside weather conditions would govern the operation of the condensing system. The minimum temperature encountered by the gas would have to be determined, and the gas at the outlet of the condensers held at that temperature, or sufficiently below to afford a reasonable factor of safety.

Of course, if we wish to remove the naphthalene from the gas, so as to let it enter the mains in a really unsaturated condition, we must adopt the method by which the gas and condensate can come to equilibrium of tension at low temperature, which means the absorption of a large amount of benzol; or we must take the tar out first, and further cool it to a temperature considerably below that which it will afterwards encounter.

Of these two systems, the last will be by far the most desirable with respect to candle-power.

The advantages of the washer cooler system may be summed up as follows:—

1. Complete removal of the tar fog at comparatively high temperatures as soon as formed.

2. Fractional condensation, or rather, a fractional distillation of the condensate on its way from top to bottom of the washing compartment.

3. Great capacity, the limit of which is yet to be determined.

4. Small ground space occupied.

5. Low initial cost.

6. A very considerable decrease in differential pressure through the condensing system.

7. Ability to deliver gas to boxes at higher temperatures, causing more effective purification.

8. Purifying material in good condition when removed from the boxes, which enables us to revivify it more rapidly and use it up to a higher percentage of sulphur.

9. Better oil results, because this system of condensation prevents the absorption of an excessive amount of benzol by the condensate, hence gives us increased candle-power.

For these reasons, though the washer cooler may not be the last word in condensation, it offers such unique and exceptional advantages over the system of slow condensation, that it must come more and more generally into use in modern water gas practice.

THE PRESIDENT: You have listened to an exceedingly interesting paper, and without calling on any one, I shall be very glad indeed to hear a full discussion of it, I should like to ask Mr. Gartley to enlighten us further on this subject.

MR. W. H. GARTLEY: On page 131 there is a table showing the difference in benzol content between the gas going into the washer scrubber and the gas coming out. This, of course, shows the quantity of benzol that has been taken out with the washing and cleaning of the gas in the washer scrubber. In other words, if I am right, the sample was taken off from the gas as it went into the washer scrubber and passed through U tubes set in a freezing mixture, and the same was done with the gas coming out. The difference in the condensates from this shocked gas would be, it was supposed, the loss in passing through the washer scrubber. First, in experiment "A," this was 0.012 grams of benzol per cu. ft. Therefore, to my mind, there seems to be an unusually

small amount of benzol in this crude gas. I therefore presume that the oil used was paraffine base oil. I should like to ask whether this was true or not?

MR. WORTHING: That was true, paraffine base oil.

MR. GARTLEY: Now going back—the gas after passing through this again and being cooled lost 1.15/100 candle-power.

MR. WORTHING: I think that you are under a misapprehension there. This candle-power test was entirely separate from the tests for loss of benzol. The candle-power test was simply a test where the gas was pumped into the holder and then at low temperature pumped through a long line of mains to another holder, where it was exposed to a low temperature some days and pumped back again. At the time the gas was made, the candle-power tests were taken and the tests were intended to show the ability of the gas to stand up under severe weather conditions, to prove that it was not a tender gas.

MR. W. H. GARTLEY: Now, going back to page 129 he states, "the test made in which the gas was allowed to stand 72 hours in an outlying holder was then pumped back to the station, during which process it had been exposed to an average temperature of 26° F., during which time it lost 1.15 C. P."

In outlet gas in test "A" he had 0.137 grams of benzol, which, as I am more accustomed to figuring in grains, is 0.137 × 15.43 or about two grains of benzol per cu. ft. in the gas coming out of the washer scrubber, which determination was made by passing the sample of gas through a freezing mixture in the presence of tar, which would surely take out as much benzol as could be expected to come out in the test from the holder and back again to the works.

Now, I should say that Mr. Worthing in making this test was unfortunate in not having a gas in which the virtues of the washer scrubber could be made more apparent, because in this gas the washer scrubber has not been proven to handle

the problem of tar extraction efficiently, as there was very little benzol in the gas to start with, and since two grains of benzol will enrich a gas about one candle, and since he only had two grains of benzol in the gas when it came out of the washer scrubber, and since he only lost 1.15 candle-power in his holder test, it does not seem to me that the treatment of the gas as shown in this paper was as severe as could be given it.

I am not criticizing the process, which appears to me to be entirely in accord with good practice, but I do want to say that I do not think the test as made in this paper particularly proves its merits.

THE PRESIDENT: I should like to hear from Mr. Henry Doherty on this subject.

MR. HENRY L. DOHERTY: Mr. Chairman, the paper under discussion deals with a process of washing and scrubbing gas of which I am the inventor. I am not responsible for bringing it before the Association and do not want to take any part in exploiting it.

THE PRESIDENT: You must not be too modest; go ahead and tell us about it.

MR. DOHERTY: In a general way the results reported by Mr. Worthing are just about what we are getting elsewhere and what was expected. My method of treating the washer cooler would be an entirely different method from the one which he has used and I doubt if I could throw any particular light upon it without going into a discussion of much greater length than I care to go into at this time. In the first place there are a few principles that are worth special consideration. First, in place of circulating a large mass of cooling water in contact with your gas, you circulate only the amount of cooling water which is represented by the condensation that comes from your gas; that is, all of the cooling water that is discharged from the system and that might carry away benzol or other valuable compounds is limited simply to that which is condensed. If you bring your gas pretty well down to that

temperature before it enters the washer cooler, the amount of water that is discharged is relatively small. If you did not have to discharge any water at all, then the water present would soon reach saturation and then no more illuminants would be taken up. I cannot answer Mr. Gartley's question. I cannot answer him in grains per hundred or anything of that sort, because I do not remember; I did not come here prepared to discuss this paper, in fact I did not know exactly what this paper related to.

The other important feature is this, that the system as carried out brings about the transfer of heat from water to water instead of from gas to water as is usually the case. The efficiency of a heat transferring surface varies tremendously with the medium on each side of it. For the same general condition you may assume that the rate of heat transfer per B. t. u. per square foot per degree per hour will be about one and one-half B. t. u. when transferring heat from gas to gas. When you are transferring heat from gas to water you will secure a transfer, we will say, of two and a half B. t. u. per square foot per hour. When you work from water to water—and this process transfers your heat through a diaphragm from water to water,—you get an efficiency of transfer of about 150 B. t. u. per square foot per hour. You get that with a clean gas and a clean water. Working with a dirty gas and a dirty water, we have gotten as low as 39 B. t. u. You could get a deposit CO so thick that it would be even lower than that, but the lowest we have so far is 39 B. t. u. Now, that means a very much smaller equipment, much less surface, and as you get direct contact between your water and your gas, you can get just as large superficial area there as you want finely dividing your streams of water and gas and bring about just as intimate a mixture between your gas and water as you wish.

This is a system of washing and cooling which we have gotten up and have used practically in our own plant. A few people have used it besides ourselves. We have not tried to

exploit it, but have simply used it as a means of cutting down the amount of scrubbing and condensing surface and getting better condensation results. It is used more extensively by the Semet-Solvay Company than it is in our own plants. We use it universally, but as they make much more gas, they use it to a greater extent than we do. We find that we can use it if we want to as a tar extractor, in addition to using it as an ammonia scrubber. In other words, we can make this apparatus take the place of every piece of apparatus between the hydraulic main and the purifier. Now, we are not advocating this practice. The system as set forth here is applied to water gas and the complete system as applied to coal gas is very much more extensive than has ever been published, and it would be an injustice to the system to describe it in an impromptu talk.

THE PRESIDENT: We should like to hear from Captain McKay on this subject.

CAPTAIN MCKAY: I am much interested in the results of this washing and scrubbing. The Boston company has had satisfactory service from the cooling of water gas with the so-called "salt water" tubular condenser. Practically the same space is occupied as is described in the author's paper, and a condenser of that size will efficiently care for between 450,000 and 500,000 cubic feet per hour. This will cool the gas to 90° or 100°, or to the temperature at which we wish to deliver it to the P. & A. tar extractor.

In relation to the operation of this Doherty cooler, the author states that the water required is only one-thirteenth of that necessary for the old-time tubular condenser. I wish to ask Mr. Worthing whether that includes also the water used to cool the circulating water.

Further on the author states that he calculates a saving of seven horse-power per hour. In computing his horse-power. has he included the horsepower used in pumping the water to cool the circulating water? If these items have been included in both cases, is the author able to state how much

water is used in the circulating system and how much is used to cool the circulating water; and how much horsepower is used in the circulating system, and how much is used to cool the circulating water?

The President: Gentlemen, does anybody want to speak on this paper?

Mr. Klumpp: On page 129 the author gives a table showing the relative heating value and candle-power of the gas after it has been treated with this scrubber-washer. Now, the heating value seems to be high, compared with the candle-power, showing evidently a very low oil efficiency, and after exposure the slight drop of candle-power shows that the quantity of benzol thrown down was very small. It seems that the oil efficiency of the gas as made could not have been much over 5.4 candles per gallon, and the gas after exposure had an efficiency of nearer five (5) candles per gallon which means, I think, that the gas is made with very little benzol in it in the first place, and, therefore, has very little benzol to lose in the scrubber-washer. It would be interesting to know the oil efficiency, because I would look for a much greater loss in candle-power, probably two or three candles, if the efficiency was around six candles per gallon. I would like to know the oil efficiency, if Mr. Worthing would give it?

The President: Before Mr. Worthing answers I should like to know if there is any other gentleman who would like to discuss the paper.

Mr. H. Russell: I am in about the same position as the other speakers, I am looking for further enlightenment. On page 131 he says, "Tar per M. cu. ft. gas separated in W. C. equals 0.096 gals. equals 0.80 lbs., equals 363 grams tar per M. cu. ft. of gas." Now, assuming that oil tar formed is about ten per cent. of the oil used and assuming three and eight-tenths gallons of oil per M. cu. ft., we would have a total amount of oil tar produced of about 38 gallons. The author states the washer cooler is only taking out 0.096,

or roughly, 25 per cent. of what we might expect in ordinary water gas practice. I suppose this washer cooler is located between the relief holder and the seal. Undoubtedly there is some loss of oil tar in the seal and possibly in the pipe leading up from the washer cooler, but the discrepancy seems to be very large. Either their measurements were not accurate or the washer cooler had not taken out anything like the amount of tar the paper would lead us to believe.

There are several points on which I should like to have information. I should like to know for instance in regard to the table on page 129, if the actual gas temperatures going into the holder at station A and the temperature of the gas coming back to the holder at station A, were taken. It also would be quite important to know just how these holders were flushed and also it would be important to have the analyses of the gas both going and coming as regards the benzol contents, and also it would be important to know whether any hygroscopic tests were made showing what the minimum temperature was which the gas actually reached at any time in the main. All these points are things which ought to be brought out before any real intelligent discussion of the paper can be had.

The author also uses the term "condensate" as though it was something rather fixed, as though you removed the condensate and that was the end of it. It is not quite clear to me what he means by that term. Is it synonymous with tar vapors or not? In other words, I am inclined to think from his paper that he gives one impression that the condensate is all taken out in the washer cooler, and such would not be the case.

THE PRESIDENT: Gentlemen, we will now give Mr. Worthing an opportunity to defend himself.

MR. WORTHING: Regarding the first question I will say that the saving of the horse-power calculated does include this; that is, we have included in the calculations the horse-power necessary to force the water through the cooling coils,

if that is what Captain McKay means. The cooling coils are right on the line to the washer cooler. The water is brought up from the well and forced through the cooling coils and from the cooling coils into the first section of the washer; and of course that horse-power has been taken into account in calculating the horse-power saved.

CAPT. McKAY: May I explain that that is not what I asked. After the body of water has cooled (the circulating water), have you calculated the horse-power required to make that water cool the circulating water?

MR. WORTHING: I will say we have calculated roughly the total amount of water pumped by the works pump, and that part of it used for cooling the circulating water and have calculated the horse-power consumed in pumping the cooling water, from that. This figure of $^1/_{13}$—that is that the washer cooler uses $^1/_{13}$th of the water required in the old form of condenser, was the figure taken before we put on our extra cooling coil and that would be now somewhat modified, but not very materially, especially in the winter time.

Concerning the oil efficiency in this test of the ability of the gas to hold its candle-power at a low temperature, I will say that the oil efficiency was more nearly 6 than 5½, and although we do not make it a practice to make as high candle-power gas as that shown in the test, and consequently do not expect under the circumstances to get such high oil efficiency, as we would if we were making lower candle-power gas, yet at the same time there was no marked diminution beyond what you would expect for the c.p. maintained and there was no reason to think that the gas was especially lacking in benzol.

Regarding Mr. Russell's first question I will say that we never use as high as 3.8 gallons per M., or at least very seldom. Our oil runs ordinarily much lower than that. Second, the washer cooler is located between the relief holder and the boxes and the tar has an excellent opportunity to deposit in the seal and in the relief holder. In fact, the great

amount of the tar does not come out after the relief holder but before that, and at a considerably higher temperature. And also, I will say, that all the condensate, that is all the tar and heavy oil left in the gas at the outlet of the relief holder, has come out in the washer cooler. We have not found any getting past at all; at least, not while we had a sufficient quantity of cooling water. We did not take any analyses of the gas in this test to determine the ability of the gas to stand up, but I will say that the gas stood in an open holder, exposed to the atmospheric temperature for 72 hours, and that it was pretty certain to come to that temperature. I do not see how it could help doing so. Furthermore the holders were flushed by pumping gas into them. We let the holders down as low as possible and pumped gas through the mains into the holders and out until we concluded the holder was sufficiently flushed. The holders were flushed with a very considerable amount of gas so that at the end of the tests we had only a little over one-half of the gas that we started with. That answers all of the questions, I think.

I do not think it is at all surprising that we got as small a quantity of benzol out of the gas as we did, because the difficulty of getting an average sample of unpurified gas is so very great as to be almost impossible. We do not know to what extent the candle-power was lowered by these freezing tests—very slightly probably—according to the figures for the gas in the endurance test. Moreover, the amount of benzol that gas can retain at the minimum temperature to which it was subjected in these tests is very considerable. Therefore it is likely the part taken out only represents a small part of that actually in the gas.

These tests were merely comparative. If there was any loss in benzol it would be due to that absorbed by the condensate in the washer cooler. I don't think that I said that this test showed the actual amount of benzol originally present in the gas.

Regarding the estimation of benzol loss calculated from the

amount present in the tar—I will say that it was as nearly as possible C. P. benzol. It was distilled from a large quantity of tar, and the resulting oil re-distilled by the ordinary method until we got a product of practically uniform boiling-point—that is, C. P. benzol.

THE PRESIDENT: There was a point the Chair had hoped some one would bring out and it has not been brought out, and I am going to ask Mr. Gartley if I correctly understood him that he would expect gas washed with saturated water to lose more benzol than would be lost by gas passing through an ordinary condenser at the same temperature, assuming the water to be saturated with the illuminants that the gas contains.

MR. GARTLEY: Will you say that again, please?

THE PRESIDENT: I understood you to say—"that you would expect gas to lose more benzol in passing through this condenser where it is washed with water already saturated with the illuminants than the same gas would lose passing through a tubular condenser cooled to the same temperature?" In the tubular condenser it would be in contact with tar, but in this other condenser it is in contact with cold water. Now, you may not have intended to say that and perhaps you did not, but that is the way I understood you.

MR. GARTLEY: No, I did not say that.

MR. DOHERTY: I don't like to break the rules of discussion but one very important point has not been brought out and it may be of advantage to know what it is. We have found in holding the candle-power, that it is very valuable to get our tar out of contact with our gas circulation. Now, by using a type of machine like this, the tar is seldom in contact with the gas, long. It is settling in the basin in the bottom of the cooled chamber and is not exposed as it is in the tar extractor where the surface keeps on absorbing the illuminants. In this process the tar is precipitated from the gas and is separated from further contact with the gas by a super-

imposed layer of water. The tar does not come back into the circulation, and the water does.

MR. GARTLEY: I want to make a suggestion of a method of condensation that was brought to my attention within the last year. The loss of benzol is a functioning of two items—temperature and contact with tar. Your tar in the condenser is flowing downward against a current of gas going upward in which the tar will meet with the warmer gas, there is the deflegmatic process going on, but as the author said in a case of this kind you would not be able to determine to what extent it went on or how much good it was doing.

That was an apparatus which looks to me to answer pretty nearly every requirement. After the gas has left the holder and before it goes into the main, it has passed through a deflegmatic column by means of a fan blower and bubbling up through this column it meets eventually with the temperature which will reduce it to the lowest temperature which will obtain in the main. As it drops its condensate, its vapors, and goes down through the column, the warm temperature that was met with in going down causes a re-vaporation and the lighter material rises again to the top until the gas going off will be necessarily freed of all the water that it would drop in the main, which can be determined by maintaining the temperature of the gas going off at the temperature of the main, which can be determined by the hydrometer, and you will have also in it every bit of vapor that there was in the gas as it entered the deflegmatic column and which would stay in the gas at the lowest temperature it met with in the main. If such a condenser were put into practice and worked through rigidly, you could get a gas that would not give any condensate after it got into the mains at all. Of course, you would find that it would be too expensive because you might be cooling a million feet of gas to a temperature in which there would be a small portion of heat in some remote place, where the main comes unusually near the surface. In this condenser you can do another thing: if you want to enrich

by benzol, it is apparent that if the benzol is admitted according to its gravity, according to its purity, if it is admitted at different points in such column, the deflegmatic process would go on in the enriching benzol, so that the heavy material would all be kept behind and every bit of the valuable enriching properties would go off with the gas and stay there. I think that that is the nearest to perfection that you can come, because if you are going to mix your gas with water at a temperature, say below 105 degrees, you are bound to get some of the condensate that will come out with the water. I think Mr. Worthing was very fortunate in having a gas that was so lean. If he had carried out his experiments with such a gas as we used to get from the Beaumont oil he would have undoubtedly a large amount of benzol vapor, perhaps ten times as much—in which the chances for the loss of candle-power might be five or six candles. We don't get that oil now, so that we are not giving anything away at the present time. But he would have found that he would have had in this water that came out after the gas had gone to 105 degrees, a large amount of benzol.

THE PRESIDENT: Gentlemen, you have heard the discussion. I think it would be very appropriate to present a vote of thanks to the author of the paper. I should be very glad to hear such a motion.

MR. GARTLEY: I move a vote of thanks to Mr. Worthing for his very valuable and interesting paper.

The motion was seconded and carried.

THE PRESIDENT: The next order of business is the paper on "Production and Market for Ammonia Products." I am going to explain that you will have that paper in your hands. At the close of the reading of it there will be a recess until other papers are handed to you and then all four papers will be discussed together. I will call on Mr. W. N. McIlravy for his paper on "Production and Marketing of Ammonia."

MR. MCILRAVY: Mr. President and Gentlemen:—Some seven or eight years ago the by-product industry saw reason

to be concerned as to the disposal of the ammonia that was coming on our market in large quantities. The producers of ammonia got together and discussed the situation and decided that the best way to cope with this condition was by working in unison through some one company and selected the American Coal Products Company, whom I represent, to act for them. It was my particular lot first, to go through the country and find out why the fertilizer people were not using more sulphate of ammonia. We went to the Agricultural Experiment Stations of each state and found that they were not recommending the use of sulphate of ammonia as a fertilizer but rather the use of nitrate of soda. We then asked the gas men to go to the Experiment Station of their state and use their influence to bring about the recommendation of sulphate of ammonia where it was produced in the State, on the ground of its being a home industry. We did not get very much encouragement in these attempts at first. However, with the money that some of the companies gave for this purpose we went to work and made experiments in different parts of the United States on different soils. We studied the different types of soils and ascertained to what extent they would respond to sulphate of ammonia, and what quantity was the best to use. Among other things, we found that in the Middle West the soil is so rich that there is very little need for sulphate of ammonia, that a good deal of by-product ammonia is made in the Middle Western district and that much is going to be made there. In the South we made experiments on cotton, and found that sulphate of ammonia gave fine results. It did not leach through the ground like nitrate of soda, and the corresponding quantity gave as good or better results.

Another question, that of tariff, came up about two years ago. There was a duty on sulphate of ammonia of 30 cents per hundred pounds, and this duty it was proposed to remove, placing the article on the free list. I called upon the gas men to stand shoulder to shoulder and help to keep

this moderate rate of protection on; but the influence of the farmer was too strong and it was taken off. This brought sulphate of ammonia down to a price of about $2.50 per hundred pounds. About two years before that, I had made a trip abroad at the suggestion of the larger manufacturers, and found that in Germany they were making demonstration experiments with sulphate of ammonia on a large scale. In fact, they had as many as twenty or thirty trained men who devoted their whole time to such work and many more who devoted a part of their time to it. In Germany, where three or four years ago they were exporting about a half of what they made they are now using all the home production, and the gentleman who is in charge of the syndicate over there stated to me when I saw him last Spring, that they would have to buy 40,000 tons in addition to what they made themselves, although their output this year is over 370,000 tons.

In England, the same conditions existed as we found at first in this country; they were not using what they produced. The largest producers got together and formed a Sulphate of Ammonia Committee, through which contributions of so much per ton of sulphate were levied, and which formed an organization for carrying on propaganda all over the United Kingdom. In this way they are endeavoring to bring up the consumption from sixty or eighty thousand tons to something nearer the 375,000 tons that they annually produce. If they will only use up what they make we can take care of ourselves. It is the imports that swamp us. In the cotton belt, which is easily reached from the seaports, we cannot compete with the sulphate imported from England, and we cannot compete when we have to ship from the Middle West to the East. To maintain the market it is necessary to create a demand in the Middle West itself; we have started to do that and we have met with very good results.

In order to accomplish what we have set out to do, every gas man, large or small, will have to put his shoulder to the

wheel and help push for sulphate of ammonia. He should not be afraid to spend a little time in propaganda work. It is unquestionably necessary, and furthermore, if we come around and ask for a donation to help out the work, he should not turn up his nose at the request because what we have already done has brought the price of sulphate of ammonia up from $2.50 per 100 pounds to $3.00 per 100 pounds. If you create the demand for sulphate of ammonia, you know that the price will take care of itself.

THE PRODUCTION AND MARKET FOR SULPHATE OF AMMONIA.

The United States now ranks third among the nations of the world producing, or perhaps we may more properly say, recovering, ammonia from coal. England last year recovered 375,000 metric tons, Germany, 373,000 metric tons, and the United States, 105,000 metric tons, reckoning all forms of ammonia as sulphate. Although the output of this country is not as yet one-third of that made in England or Germany, its potential production is nearly as great as that of both these countries together. Therefore a study of present conditions is of value at this time as it may cast some light on the character of the development that it seems extremely probable the near future will bring.

About 74 per cent. of the estimated production of the United States for 1910 came from by-product coke ovens and the prospects are that any considerable increase in the production of the country will come from this source. Some years ago it seemed that the use of coal gas was on the increase and if that tendency had persisted we might have looked forward to a recovery of ammonia from this source that would in time rival the figures reached in England, where nearly one-half of her immense annual output is from this source. As is well known to gas men, however, the discovery of new supplies of petroleum west of the Mississippi river has had the effect of lowering the cost of carburetted water-gas and the normal increase in the gas consumption in the country

being largely if not entirely covered by gas made in this way rather than by coal gas. So far as figures are obtainable there has not been any appreciable increase in the coal gas production of the country since 1907. The prospects and performances of the by-product coke oven therefore will bulk large in this paper. However, the dividing line between the by-product coke oven and the coal gas industry proper is becoming less and less distinct, and the discussion of matters affecting so important a residual as ammonia is of vital interest to every gas man.

Sources of the world's production:—

The United States is not the only country in which the by-product coke oven plays the principal figure in ammonia production. In England, the greatest coal gas country in the world, the proportion of the sulphate of ammonia produced in coal gas works is but 47 per cent. of the total output, while the by-product coke oven produces 26 per cent., and has more than doubled in the last five years. (For table of England's production see appendix). England has other sources of ammonia production, the principal one being the blast-furnaces in Scotland where the use of a splint coal makes the recovery of ammonia from furnace gas possible, the shale oil industry, the recovery gas producers, (Mond., etc.) and the bone carbonizing industry. But out of a total increase of 28 per cent., in the last five years, the gas works have supplied 4 per cent,, the other sources 6 per cent. while the coke ovens may claim 18 per cent., or over two-thirds of the total five years increase. England consumes but 87,000 tons of her annual production, exporting the rest to all quarters of the globe.

In Germany the by-product coke ovens play by far the greatest role. The production from this source is given as 84 per cent. of the total, the balance being principally due to the coal gas works. (For table of Germany's production see appendix). The feature of the German industry is the tremendous annual increases that have been regularly made.

The output of 190,000 tons in 1905 was increased to 377,000 tons in 1910, or nearly double in six years. And here we may pause to note the fact that by efficient and far sighted propaganda the German market has been educated to consume the entire home production.

In the United States the total production for 1910 was about 116,000 net tons, of which the by-product coke ovens made 86,000 tons.

The figures for the production of sulphate of ammonia and sulphate equivalent (see appendix) show that the output of the country, which was 17,000 tons in 1898 doubled itself by 1902, a space of four years, doubled itself again by 1906, and while it has not doubled itself in 1910, the increment has been greater than for any other preceding four years. In the last period it should be noted there occurred a business depression in 1908, causing the first set back in the constantly advancing figures of production.

The figures for the percentage of the total output due to the coke ovens show also that the increase has been constant except for the depression in 1907-8 already referred to.

The coal carbonized in the coke ovens, as reported for 1910 amounts to 9,456,000 net tons, which indicates a recovery of 0.91 per cent. of sulphate of ammonia on an average. Considering that several of the plants are operated on low volatile coal, which yields but little ammonia, this figure speaks fairly well for prevailing standards of practice.

In France the sources of production include the shale works and sewage disposal as well as gas works and by-product coke ovens. The by-product coke ovens form the largest single item, amounting to 47 per cent. of the whole, and the only one that seems to be increasing. (See appendix.)

The production of the other countries of the world is small in relation to those already discussed and, although some of them possess coal, and therefore are potential producers of ammonia, their industries are not yet developed to a degree that promises any considerable recovery in the near future.

The details of the world's production are given in the table

(See appendix.) In examining this table it will be noted that to facilitate tabulation all long and net tons have been reduced to metric tons.

The aggregate output of the world is over 1,050,000 tons of sulphate of ammonia, representing 262,500 tons of nitrogen. The export of nitrate of soda from Chile for the year 1910 is given as 2,251,000 tons, or about 349,000 tons of nitrogen. Therefore of a total of 611,500 tons of combined nitrogen furnished, sulphate of ammonia supplies 43 per cent. As the corresponding figure for last year was 40 per cent., there has been a small gain for sulphate of ammonia. Since there is far more nitrate of soda used for purposes outside of agriculture than there is sulphate of ammonia, it is probable that, of the two, sulphate of ammonia actually supplies the most nitrogen for use in fertilizers.

As regards the possible development of any of the minor English and French ammonia producing industries in the United States it may be said that the recovery from blast furnace gas is due to the use of splint coal, and does not seem at all likely to be introduced in this country. The distillation of shale, a source from which the United Kingdom now derives 60,000 tons of sulphate equivalent per year, has not as yet been established in the United States, although it is stated that suitable shale exists in certain regions, and the industry may therefore obtain a foothold at some later date. The carbonization of bone is carried on in the country to some extent, and ammonia is produced by this process, but it is not increasing, and does not hold out any promise of doing so. The recovery of ammonia from gas producers, in which direction England has made some progress, has not made any advances of importance lately. In addition to these processes there is the possibility or we may even say the probability that some one of the new methods of producing ammonia as such from the atmosphere may come into commercial importance, notably the process recently discovered by Prof. Haber, but it is too early as yet to hazard any definite predictions in this direction.

A review of the situation, therefore forces us to the conclusion that the by-product coke oven is at present the largest producer of ammonia, and promises to be the principal source of increase in ammonia production for the immediate future.

Relation of present to possible ammonia recovery:

Generally speaking, bituminous coal will yield 1 per cent. of its weight in sulphate of ammonia if treated by dry distillation, therefore the possible ammonia production of the country would be 1 per cent. of its consumption of bituminous coal. But the present methods of consuming coal are far from realizing any such ideal; nor does there seem likely to be any great change in the near future. It is, however, reasonable to reckon that every ton of coal that is actually subjected to dry distillation should be called upon to yield its quota of sulphate of ammonia. Such a calculation would show within reasonable limits the development that by-product recovery has reached in the countries considered, and indicate the possibility for extension. Fairly approximate figures of this kind are accessible for England, Germany and the United States.

In the United Kingdom the coal treated in coke ovens of all kinds and in coal gas works in 1908 amounted to 35,233,523 tons. The sulphate of ammonia that could have been produced, according to the average figures for modern practice, may be estimated at 1 per cent., or 352,335 tons. The amount actually produced from coal in this year, according to the official reports given further on, was 248,100 tons or 70 per cent. of what might be designated as recoverable. In other words, the efficiency of England's ammonia recovery is 70 per cent.

Since 1908 the English production has increased to 369,000 tons of sulphate of ammonia in 1910, and as most of the increase is in the amounts derived from coal, the efficiency figure is probably even higher than has been given. For 1906 the efficiency was 57 per cent., which shows a decided gain since then.

The production of metallurgical coke in Germany in 1910

was 23,600,362 tons, which corresponds to a coal carbonization of about 33,700,000 tons. Using the same percentage figure as for England, this coal should theoretically have produced 337,000 tons of sulphate of ammonia. The actual production of the country was 373,000 tons, of which 60,000 tons may be reckoned as coming from the gas works, leaving 313,000 tons as the actual recovery from the coke works. This is 93 per cent. of the theoretical, and indicates the general use of recovery appliances in the coking industry. This figure also shows that Germany has nearly reached the maximum production to be expected from the amount of coke now made.

In the United States the latest official figures available are for 1909. The coal coked in by-product and beehive ovens was 59,354,937 net tons, and in addition there was about 3,600,000 tons used in coal gas making, about 63,000,000 tons of coal in all. This should have yielded 630,000 net tons of sulphate of ammonia or its equivalent. Actually but 106,500 tons were produced, or 17 per cent. In 1907 this figure was 15 per cent., so there has been a small gain.

If we compare these efficiency figures, we are compelled to admit that England and Germany lead the United States not only in the proportion of recoverable ammonia which they save, but also in the rate at which this figure is increasing. The United States cokes nearly as much coal as both countries put together, yet produces less than one-sixth as much ammonia.

It cannot be stated that the quality of coal available in Germany or England is better suited to by-product recovery, nor are there other natural conditions that particularly favor these countries; it is merely a question of developing the industry. Looking at it in this way it may seem that the United States has made but little progress in by-product recovery, but there is something to be said on both sides of this question. Important changes in so large an industry always require time, and in spite of the loss of valuable by-products that has gone

on for years in the beehive coke plants, the business has generally speaking, been profitable. There are over 100,000 beehive ovens in existence in the United States representing an investment of many millions of dollars, a large part of which would be lost if the change were made.

The probable direction of by-product coke oven development:—

The by-product coke oven is, generally speaking, a tributary of the blast furnace. Although a considerable tonnage of coke is used in foundries and for domestic and industrial fuel purposes, by far the major part of the coke consumed in the United States goes to make pig iron. This seems likely to be the fact for some years to come, at least. The natural location for the coking plant therefore is between the coal mine and the iron works.

Most of the beehive coking plants are located at the coal mines, for various reasons, among which no doubt is the fact that the wasted by-products make so much smoke and annoyance that they would not be tolerated except in the thinly populated coal regions. In the case of the by-product plant, however, it has been found that the process can be carried on in or near large cities, and that this location offers a better chance to dispose of the residuals, particularly the gas. Thus it has come about that the recovery plants are being generally located near the blast furnaces rather than near the coal mines. Other reasons, as the ease of shipping coal rather than coke, favorable freights and the desirability of mixing several kinds of coal, tend in the same direction. The latest large steel works, as those at Buffalo, Joliet and Gary, are incorporating the by-product ovens with the steel plant. These facts have an important effect in determining the geography of sulphate of ammonia production. Also, because of the great area of the United States, they strongly influence its distribution.

Although the supply of coking coal in the United States is very large, the coal fields are confined to certain districts. Their location may be seen by glancing at the map, on which

the existing by-product coking plants are also shown. (See Figs. 1 and 2.)

Three important coal fields and all of the by-product cok-

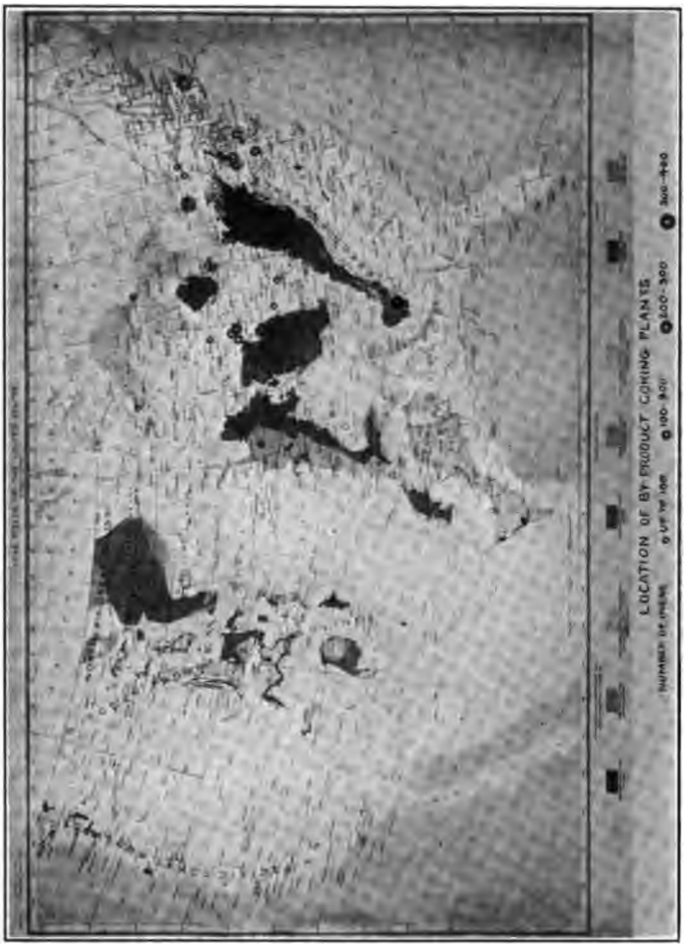


Fig. 1.—Map of coal fields of United States showing location of by-product coking plants.

ing plants lie to the east of the Mississippi River. The largest and by far the most important field is known as the Appalachian Region. It begins in western Pennsylvania and eastern

Ohio, extends in a south-westerly direction across West Virginia and Kentucky, decreases in width as it crosses Tennessee, and comes to an end in Alabama. It is with this field that we

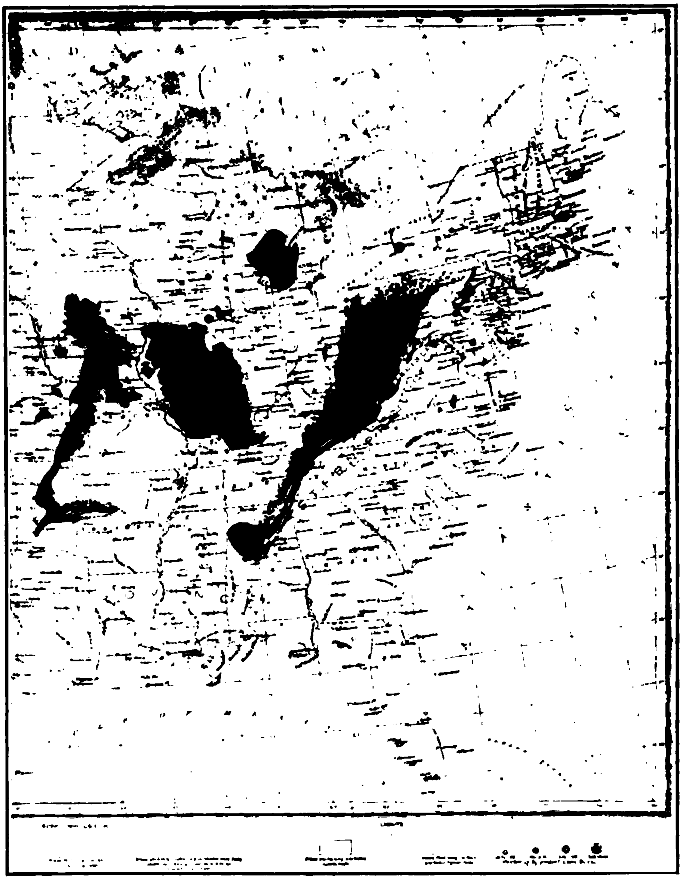


Fig. 2.—Map of coal fields of United States showing location of by-product coking plants, larger scale.

are principally concerned, as much of it, more particularly the eastern portion, is of satisfactory coking quality. The coal produced in the Northern Region, lying wholly in Michigan,

is not of coking quality, and of the extensive coal beds in the Eastern Region, lying in Illinois and the western portion of Indiana and Kentucky, only a limited area in the southern part produces merchantable coke.

There is some coking coal in the southern part of the Western region, lying in the state of Oklahoma, and there is also some in the Mountain and in the San Juan Regions, in Colorado and New Mexico, but there does not appear to be any immediate prospect of by-product ovens being erected there. The same statement is true of the coking coal field lying near Seattle, in the state of Washington.

We return, therefore to the consideration of the Appalachian Region. Nearly all the existing recovery plants obtain their coal from its mines, and it is probable that most of the plants built in the near future will do the same. The operating plants arrange themselves naturally in a Northern group of twenty-five establishments and a Southern group, of three establishments. It is noticeable that few of the existing plants in the Northern group lie within the coal region, and that some are at a considerable distance from it. As a matter of fact, the first plants built to make blast furnace coke were in the Pittsburg district, adjacent to the blast furnaces there. Later plants were built to take care of the furnaces lying to the east at Baltimore, Lebanon, Harrisburg and Chester, and at Boston and at Camden for gas production. Nevertheless the tendency of the steel industry is not now in this direction, but rather towards the west, because of the supplies of iron ore available on the great lakes. The result of this tendency has been the building of the large plants at Buffalo, Detroit, Joliet, Gary, Milwaukee, Duluth and Sault Ste Marie, the latter just over the Canadian line. Therefore, reasoning from what has been done, and considering the direction in which new construction is being planned, it seems certain that the center of by-product coke production, and therefore of sulphate of ammonia recovery as well, will be in the vicinity of Chicago. As we have not only to consider the production of sulphate of ammonia, but also its profitable disposal, these

facts are of prime importance to us. Unfortunately the probable center of sulphate of ammonia production is not at all where market conditions are at present most favorable. Sulphate of ammonia being a by-product cannot have its point of production chosen with particular reference to the facilities for disposing of it.

Market for Sulphate of Ammonia:—

It should be stated in the first place that any increase of our present production of ammonia must be marketed as sulphate. The consumption of ammonia in the form of concentrated liquor, and similar forms, is always taken care of first, as these forms do not require outlay for acid on the one hand and are more difficult of shipment on the other, which tends to reduce foreign competition. Although a certain amount of sulphate of ammonia is used in chemical manufacture it is relatively small, the principal use of this article being in agriculture as a carrier of nitrogen, therefore we may regard the fertilizer market as the only one to be considered in discussing the future prospects of the sulphate of ammonia disposal. Consequently the states in which the consumption of artificial fertilizers is the largest are those in which the market for sulphate of ammonia is to be found. Generally speaking the need of fertilizers in the United States is very great, although the consumption is impressive, being estimated for the year 1910 at nearly 6,000,000 tons, valued at $118,000,000. The area of improved farm land according to the census of 1910, amounted to 477,448,000 acres. Therefore the American farmer applied a little less than 25 lbs. of commercial fertilizer per acre to his land that year, costing about 25 cents. This is a very low figure, and indicates a possibility of considerable extension. It should be considered, however, that a great deal of stable manure is also used as a fertilizer and besides that in some of larger agricultural states almost no fertilizer at all is used, which tends to increase the average of other States.

Unfortunately the largest fertilizer consuming districts do not lie anywhere near the center of sulphate of ammonia pro-

ductions. This may be readily seen by inspecting the accompanying table of the fertilizer consumption of the various states for the past year. (See appendix.) The four states at the head of the list, Georgia, North and South Carolina, and Alabama account for over three million tons, and the adjacent states of Florida, Mississippi and Louisiana consume nearly half a million tons more. This is 58 per cent. of the total estimated consumption of the United States; the amount expended by the consumer for these fertilizers was over $60,000,000.

Yet the only accessible source of domestic sulphate of ammonia supply to these seven states, which have an area greater than the German Empire and Austria together, is the by-product coking plants near Birmingham, Ala., at the lower end of Appalachian Coal Region.

Unfortunately the coal gas industry of these states holds out little help. According to Brown's Directory the total coal carbonized in the 36 plants that make coal gas at all in these seven states, would only yield 1,400 tons of sulphate of ammonia, if it were all saved. As many of the plants are small, a great deal of this is not recovered at all.

The by-product oven plants at Chicago, are about 700 miles away and the freight makes such shipments practically out of the question, when we consider the low cost at which the producers of England and Germany can place sulphate of ammonia at the Atlantic and Gulf Ports. This is one of the important difficulties that lie in the way of developing the market for our future sulphate of ammonia production, and which renders the adoption of well-considered propaganda methods essential to success.

The value of the crops produced in these states is enormous. Together with Eastern Texas, Arkansas, Tennessee, and Indian Territory, they produce practically all of the cotton crop, valued at $900,000,000 this year; this is the most valuable of any crop produced in the United States, except corn, and of this crop the Secretary of Agriculture credits the South-

ern States with one-third, or a value of $500,000,000 for last year.

In addition to this the South is responsible for over $300,000,000 worth of wheat, tobacco, hay, oats, sugar, and rice, besides other cereals, fruits, and vegetables. A large portion of the land on which these crops are raised is most responsive to proper fertilization, and particularly to a supply of nitrogen. In many districts no farmers expect to raise a crop unless fertilizer is used. This is especially true of the cotton crop, yet there is much room for improvement, in that the average yield per acre for the last four years has been barely over one-third bale, whereas, three times as much is easily within reach if proper means are used. The map showing the yield per acre graphically represented by shaded areas, indicates this clearly. (See Fig. 3.) The darkest areas indicate the districts of highest yield, the lighter color showing a crop of under one-half bale per acre. Yet there is an acre of poor land near Athens, Ga., which has been fertilized with sulphate of ammonia and which will yield between two and three bales of cotton this year.

Much of the needed fertility has been supplied in the past by cotton-seed and cotton-seed meal. This valuable fertilizer, formerly burned in heaps as waste, is now fully appreciated, but a new and wide field has been found for it as a stock food, in this country, for which purpose it has long been used abroad. Its price has risen so much that it can no longer be freely used as a fertilizer, and as its higher value seems likely to be permanent, a substitute must be found. This need sulphate of ammonia is admirably calculated to fill. Its use as a top dressing on cotton has been very successful and has received unqualified endorsement from agricultural authorities. What a general adoption of sulphate of ammonia in the mixed fertilizers that are used at the present stage of progress would mean may be approximated by supposing that the three and one-half million tons of commercial fertilizer now annually used in the seven states already referred to, were of

Fig. 3.—Yield of cotton in United States.

the familiar low grade 2-8-2 formula, and contained therefore,

2-8-2 FORMULA.

Two per cent nitrogen.
Eight per cent. phosphoric acid.
Two per cent. potash.

200 lbs. of sulphate of ammonia to the ton. This alone would require 350,000 tons of sulphate of ammonia, without allowing for the probable increase in fertilizer consumption.

We have so far been discussing the very favorable conditions for fertilizer development in the states which the larger American producers of sulphate of ammonia practically cannot reach. Let us see what are the conditions that prevail in the States near Chicago, the assumed geographical center of sulphate of ammonia production.

We can hardly do this better than by looking at the diagram, which shows the yield of corn per acre in the United States. The densely shaded portions correspond to a yield of 40 bushels per acre and over, while the lighter tinted areas denote 30, 20, 10 and less than 10 bushels per acre. The area of no corn production is left white.

As corn is a very widely distributed crop and forms part of most farm rotations in practically all sections, the diagram also indicates fairly well the farming areas of the United States. Considering only the eastern, fully shaded portion, we find that the section of the highest yield is clearly the strip beginning in Ohio, crossing Indiana and Illinois, and ending in Iowa. This is the celebrated corn belt, and is noted for rich farms, and prosperous farmers. But the soil is the prairie sod, of great depth and stored with humus and nitrogen by centuries of undisturbed growth. In spite of the years of cultivation that it has had it still yields generous crops with little or no fertilizer. It is stated by the agronomist of the Illinois Experiment Station, that in the course of repeated experiments with nitrogenous fertilizers for field crops on the soils of the State, they cannot find that an increase in yield is obtained sufficient to pay for the fertilizer. This state-

Fig. 4.—Yield of corn in United States.

ment applied to nitrogen alone, however; applications of phosphoric acid, particularly as ground undissolved rock, seem to yield excellent results. The fact seems to be, that the soil is still possessed of sufficient nitrogenous matter to withstand the demands made upon it. Of course, this resource cannot always remain intact, if continually drawn upon, but the present system of agriculture carried on seems to succeed without a nitrogenous fertilizer.

This is indicated by the figure for fertilizer consumption in Illinois, 32,000 tons for 1910, as given in the table. Much of this consumption is ground phosphate rock, untreated. Some complete fertilizer is used in market garden crops, but then again the local conditions are unfavorable, as the large stock yards in Chicago and East St. Louis, sell a great deal of manure at a low price to the gardeners within railroad hauling distance. Unfortunately, this is directly in the center of sulphate of ammonia production.

In Indiana and in Ohio, conditions are much more favorable. The fertilizer consumption of both these states is fairly large, 175,000 for Ohio and 150,000 for Indiana, and, particularly in Ohio the need of fertilizers is being strongly felt. The soil, formerly having the same resources of plant food as possessed by the present Illinois land, has finally become depleted, and must be restored.

It may be noted here that this region still enjoys a supply of natural gas, which seriously diminishes the use of coal gas and the consequent recovery of ammonia.

The states lying east of Ohio are in the same general condition. Short sighted agricultural methods have robbed the soil and fertilizers are needed to restore it. The agriculture grows more intensive as we come east, and the quantities of fertilizers used per acre are larger, although the smaller area in improved farm lands cuts down the actual total. In Michigan and Ohio the sugar-beet industry has taken hold, and this promises to be a favorable outlet for sulphate of ammonia. The value of the sugar output last year was about $10,000,000 for this district. But little fertilizer is used as yet in beet cul-

tivation, but the need is becoming apparent, and will surely increase. Especial attention is being given to the development of this outlet for sulphate of ammonia.

If we consider the farming lands lying West and Northwest from Chicago, we find conditions very different from those in the East.

The states of Wisconsin, Minnesota, Iowa, Missouri, the Dakotas, Nebraska, and Kansas, produce 57 per cent. of the wheat, 48 per cent. of the oats, 37 per cent. of the corn, and 31 per cent. of the hay, grown in the United States. They comprise ⅓ of the total improved farm area of the whole country.

Yet their present use of fertilizers is practically nothing. Aside from Missouri, which is about on a par with Illinois, the total for the other seven states is hardly over 11,000 tons. Their tremendous crop totals are raised by virtue of the stored up fertility of the soil alone.

The great importance of this Northwestern region as far as agricultural products go may be seen by glancing at the map showing the centers of number of farms, area, cotton and cereal production, etc. (See Figure 5.) According to this diagram all the centers given lie a little West and South of Chicago with the exception of cotton production, which we have already seen lies in Mississippi and the center of manufacturing, which lies near the middle of Ohio.

Although the Dakotas, Nebraska and Kansas are about as far from Chicago as the Southern States already discussed, they are still further from the sea coast, and will ultimately draw on the Chicago field for additional nitrogen. The indications are that the nearer states, Wisconsin, Minnesota, Iowa and Missouri will need nitrogen first.

We cannot expect the natural fertility of the Northwestern states to continue indefinitely. In fact, they already show signs of diminished reserves, in that the yield per acre of some crops is stationary, or is dropping slightly, instead of constantly gaining, as should be the result of economic farm-

ing on new ground. The actual yield of wheat pèr acre is 13.7 bushels, of oats 28 bushels, of barley 24 bushels, while

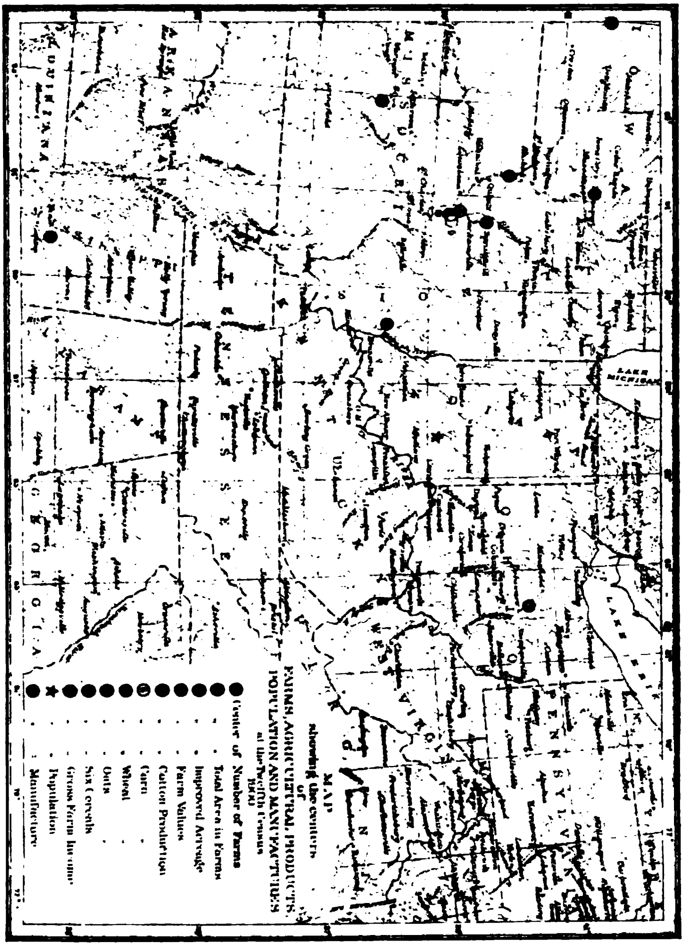


Fig. 5.—Centers of population, etc.

the averages of England are 32 bushels of wheat, 42 bushels of oats and 34 bushels of barley. The yields for these states average but little higher than those for the whole United States, in spite of the rich soil and suitable crops. They may

be said to represent extensive and depleting rather than intensive and enriching agriculture. The need for fertilizers when it does come, will find the production of sulphate of ammonia close at hand.

In the meanwhile, it has been necessary for our propaganda to overcome the handicap that the disposal of sulphate of ammonia has been laboring under because of the distance of the most advantageous market and the relative lack of nearby consumption. Owing to the general use of ready mixed fertilizers by the American farmer, and to the long campaign of education necessary to bring him to buy and mix the single ingredients for himself, no special effort has yet been made to promote the retail demand. The advantages of using sulphate of ammonia have been persistently called to the attention of the manufacturers of mixed fertilizers, and the entire domestic production has been disposed of to them. No difficulty whatever has been experienced by them in its use and in fact, it is rapidly coming to be preferred as a carrier of nitrogen.

The field experiment work that has been done with the farmers has helped in this, as it has made them favorably disposed towards sulphate of ammonia and caused them to specify it in the mixtures they call for.

It should be remembered in this connection that one of the strongest competitors that sulphate of ammonia has to encounter in the Northern and Middle Western Districts is the large quantity of so-called animal "ammoniates" produced in the meat packing plants. The constant advertising they have received and the resulting experience in their use has made the farmers in the Districts in question favorably disposed toward them and the use of this form of nitrogen in the mixed fertilizer is frequently preferred. The amount of these "ammoniates" is not actually known, but it has been stated as equivalent to 70,000 tons of ammonia or 240,000 tons of sulphate of ammonia. It should be remembered that the supply of nitrogen in this form has practically been taken up by the

market in advance of the introduction of sulphate of ammonia in any large amount. The use of nitrate of soda of which 544,559 tons were imported in 1910, also has to be reckoned with, although it should be noted in this connection that at least one-half of this nitrate of soda was used for acid manufacture, explosives, and different uses other than as a fertilizer. While nitrate of soda is unquestionably an efficient form of nitrogen, its use in mixed fertilizers presents certain difficulties because of its deliquescent character, which causes the mixture to cake, and because of the chemical action that takes place between it and acid phosphate.

U. S. IMPORTS NITRATE OF SODA, 1905.

	Net tons		Per cent.
Fertilizers	42,213	=	13
Dyes and chemicals	38,309	=	12
Glass	11,915	=	4
Explosives	134,034	=	41
Acid Mnfg.	29,301	=	9
Unaccounted for	67,937	=	21
Total Import	322,709		

Much propaganda work has been done with the manufacturers in the way of calling their attention to these well known facts and suggesting the remedy, and the result has been entirely satisfactory to them, as is shown by the increased demand and the attendant rise in price.

Consumption and Average Price of Ammonia in the United States:

The consumption of sulphate of ammonia and sulphate equivalent in the United States ranks next to that of Germany. The figures of imports and consumption are given in the table. (See appendix.)

The salient point that appears in the import figures is the increase that has taken since 1909, the amounts having jumped from 40,192 tons to 63,178 tons, an advance of over 50 per cent. Moreover, this advance is not merely temporary. The

import figures are for the fiscal year ending June 30th, but if we take the calendar year ending December 31st, 1910, we find that the imports actually amounted to 83,000 tons, or double the figure for the year preceding. For the fiscal year just ended on June 30, 1911, the imports were 103,251 net tons, or 20,000 tons in excess of the calendar year and 68 per cent. more than the last fiscal year. In all probability the consumption of 1911 will approach 225,000 tons.

In examining the average price figures given in the table it should be borne in mind that in August 1909, the existing rate of duty of $6.00 per ton on sulphate of ammonia was removed and the article placed on the free list. This accounts for the drop in price for the year 1909, and also in part for the low price figure in 1910. A fairer idea of the actual movement of prices is given by the table of weekly quotations for the past two years from which it is evident that the fall in prices due to the removal of the duty has been gradually regained, in that the present price is practically at the same level as it was before the duty was removed. From this we may infer that the law of supply and demand, reinforced by effective propaganda methods can be made to supply the place of a protective tariff.

PROPAGANDA FOR SULPHATE OF AMMONIA.

The need for a comprehensive propaganda for sulphate of ammonia has been apparent to those closely in touch with conditions, for a long time. The other materials that are used in making fertilizers, as potash salts, nitrate of soda, superphosphates, basic slag etc., have found a propaganda essential, Germany, for example, is the home of the potash monopoly, and this essential element of a complete fertilizer can only be obtained there in any quantity, yet they have carried on a propaganda for twenty years and their organization is probably the strongest and most complete of any, covering not only Germany, but nearly all foreign countries. It is regarded by them as the basis of their commercial success.

In the same way, there is an energetic propaganda carried

on in the agricultural countries of the world for nitrate of soda, the great competitor of sulphate of ammonia.

If such methods are necessary for articles like potash and nitrate, the output of which can be raised or lowered, within reasonable limits, with reference to the varying demand, how much more is it needed for a product like sulphate of ammonia, which is a by-product and is made entirely with reference to the demand for coke and gas, rather than to its own market prospects.

The Germans were the first to undertake this work for sulphate of ammonia, and they have covered the country so well that the home consumption amounted to 350,000 tons in 1910, and in 1911 will probably exceed the home production, in spite of its rapid increase.

This has been done by advertising in suitable channels, publishing bulletins, giving lectures, but before all, by actual field tests, made on plots chosen on the farmer's own fields, where all can see and note the results. Hundreds and even thousands of such tests are made every year. The material so obtained is used as the basis of bulletins, and pamphlets.

An organization comprising a central office and twenty-two branch offices, in charge of trained agriculturists, is maintained in Germany alone. Each office has its assigned territory which it covers through a number of coöperative agents, who make addresses, carry on experiments and give information, but no sales are made. The wholesale trade is supplied from the central office, and the retail from the local dealers.

The results that have been obtained in this way have lead to the beginning of similar work in France, Belgium, Holland, Denmark, England, and in our own country. England, the worlds largest producer, was especially in need of such measures, since four-fifths of her output has to be placed on the export market, instead of going on her own farms, where much of it could be profitably used. England's propaganda has now been under way two years, and results are already apparent.

In the United States propaganda has been carried on for a number of years past, on a gradually increasing scale.

At first the work was done only with the manufacturers, as the immediate consumers, to which we have already referred, but five years ago the necessity of work that would appeal to the ultimate consumer, the farmer, was apparent. It should be borne in mind in this connection that really valuable agricultural data of this character cannot be obtained in one or two seasons, therefor an early start was most advisable.

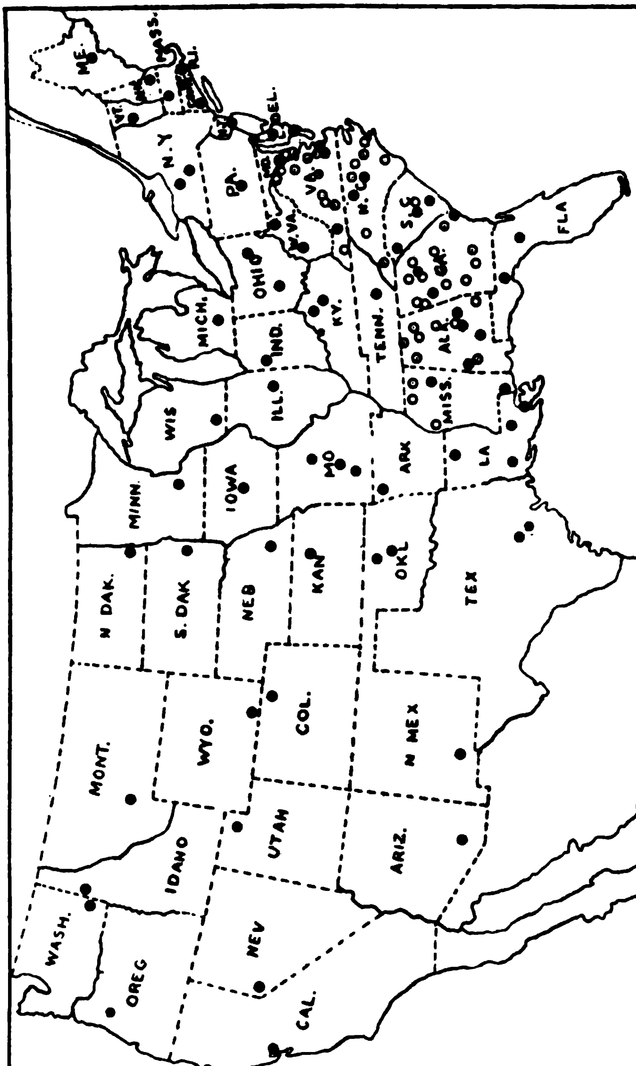
As the conditions did not favor a direct appeal to the farmer, the work was taken up with the State Agricultural Experiment Stations. There is at least one of these in each state and territory in the Union, and in some there are two or three, the total number being 63. In addition to this there is an Agricultural College in each state, in some cases located at the Experiment Station, in others elsewhere. The Experiment Stations frequently have several outlying demonstration farms or sub-stations under their control and in some states, notably Virginia, Alabama and Georgia, there is a complete system of secondary agricultural schools tributary to the Agricultural College.

In addition to these two organizations the U. S. Government maintains an extensive research department known as the Bureau of Plant Industry. The bureau conducts tests and investigations along certain lines, frequently coöperating with the Experiment Stations.

The distribution of the Experiment Stations is shown on the diagram, which also shows the agricultural colleges where they are separate from the stations and the secondary agricultural schools, also the sub-stations. (See Fig. 6.)

Working through the directors of the various stations East of the Mississippi, and some of those west of it, as far as Colorado and Wyoming, by means of personal visits, lectures, and correspondence, we have elicted the support of most of them in our propaganda. Many of them have included sulphate of ammonia in their scheme of experiments, and we regularly supply them with sufficient for their purposes. As

a result of this work bulletins have been published giving the results of successful tests and advocating its use; where form-



● THE AGRICULTURAL EXPERIMENT STATIONS AND COLLEGES OF THE UNITED STATES
○ THE EXPERIMENT SUB-STATIONS AND AGRICULTURAL HIGH SCHOOLS.

Fig. 6.—Location of agricultural experiment stations, etc.

erly no mention was made of it, sulphate of ammonia is now receiving its share of attention.

The same line of approach has been followed with the separate agricultural colleges, and many of them have found a place for experiments with sulphate of ammonia as a part of their farm demonstration work.

The secondary agricultural schools have been enlisted in the same manner, by suggesting experiments, donating the fertilizers, and in some cases standing part of the further expense involved. This work is particularly important, as it reaches the boys and young men who do not go to college, but go back to the farm. Through the Experiment Stations and Colleges we also reach the Farmer's Institutes, Corn Clubs, etc. In South Carolina twenty boys are carrying out a practical farming experiment with sulphate of ammonia, under direction of the Experiment Station authorities, who supervise the work and report it to us. Through the coöperation of the Bureau of Plant Industry we have been able to have sulphate of ammonia included in an extensive series of tobacco, corn, grass rotation experiments carried on in four states, Maryland, North Carolina, South Carolina and Virginia, under expert supervision to continue for several years. The results of this work cannot but be most valuable to us. Already the showing made by sulphate of ammonia has been most favorable.

The matter of farm demonstrations has been taken up on a much more extensive scale this year. Two agencies have been established, in charge of trained agriculturists, one in Athens, Georgia, and one in Cleveland, Ohio. The men in charge devote their entire attention to obtaining experiments with the farmers in their territory, and coöperate with the State Experiment Stations and agricultural schools, wherever sulphate of ammonia can be introduced. These representatives do not attempt to sell, either to farmers or to manufacturers. Particular stress is laid, however, on the kind of tests they undertake, as it is relatively easy to put out a large number of experiments, but not so easy to obtain any results of value for advertising purposes from them. As no immediate sales

are expected from our experiments, until the retail trade shall be taken up, their value is largely for propaganda literature later on.

Before all it is essential that work of this character should be carried out with a high standard, and that advice as to the use of sulphate of ammonia should be such as will enlist the endorsement of recognized agricultural experts. Only in this way can a substantial and enduring reputation be built up. And if we look beyond the immediate commercial ends that such a propaganda must necessarily serve, we will see that it is really an active educational force on the one hand, and an aid in promoting the conservation of our natural resources on the other. It helps to transform a noxious waste into soil fertility and beneficent growth. It is a movement that the gas and coke industries have a reason to be proud of.

APPENDIX.

Ammonium Sulphate and Sulphate Equivalent Produced in France.

(Tons of 2204.6 lbs.)

	1908	1909	1910
Gas works, Paris and vicinity	14,000	14,000	17,000
Provincial gas works	4,000	4,000	
By-product coke ovens	21,700	22,800	26,500
Sewage disposal	11,500	11,300	11,500
Shale works	900	900	1,000
Various sources	500	500	
Total	52,600	53,600	56,000

These figures are from the Alkali Inspector's reports, except for 1910, which are estimates given out by Messrs. Bradbury & Hirsch.

The figures for coke oven production are from actual reports by operating plants or from "Mineral Resources." Those for coal gas production are from "Mineral Resources," where obtainable, with allowance made for bone-black production.

AMMONIUM SULPHATE AND SULPHATE EQUIVALENT PRODUCED IN THE UNITED KINGDOM

(Tons of 2,240 lbs.)

Year	1903	1904	1905	1906	1907	1908	1909	1910
Gas works	140,489	150,957	155,957	157,160	165,474	165,218	164,275	168,000
Iron works	10,119	19,568	20,376	21,284	21,024	18,131	20,228	21,000
Shale works	37,353	42,486	46,344	48,534	51,338	53,628	57,048	60,000
Coke oven	17,438	20,848	30,732	43,677	53,572	64,227	82,886	120,000
Producer gas and carbonizing works	10,265	12,880	15,705	18,736	21,873	24,024	24,705	
Total	233,664	245,990	269,114	289,391	313,281	325,228	349,143	369,000

These figures are from the alkali inspector's reports, except for 1910, which are estimates given out by Messrs. Bradbury & Hirsch.

PRODUCTION OF AMMONIUM SULPHATE AND SULPHATE EQUIVALENT FROM BY-PRODUCT COKE OVENS AND GAS WORKS IN GERMANY (a)

(In metric tons of 2,240.6 lbs.)

Year	1902	1903	1904	1905	1906	1907	1908	1909	1910
Coke ovens	117,000	120,000	152,000	168,000	——	257,000	——	270,000	314,000
Gas works	18,000	20,000	21,000	22,000	——	(b)30,000	——	60,000	60,000
Total	135,000	140,000	173,000	190,000	(b)235,000	(b)287,000	(b)313,000	(b)330,000	(b)373,000

(a) Dr. N. Caro, Zeit. f. angew. Chem., Sept. 14, 1906.

(b) Deutsche Ammoniak-Verkaufs-Vereinigung, 1906-'07-'08-'09-'10.

United States Ammonia Production, Expressed in Sulphate Equivalent

(Tons of 2,000 lbs.)

	1898	1899	1900	1901	1902	1903	1904
By-product coke ovens	3,600	6,000	13,800	15,279	18,483	24,098	32,653
Coal gas and bone carbonizing works	13,400	a13,500	a13,800	a14,000	a17,641	17,775	22,011
Total	17,000	19,500	27,600	29,279	36,124	41,873	54,664
Per cent. from coke ovens	21.0	31.0	50.0	52.0	51.0	57.0	60.0

	1905	1906	1907	1908	1909	1910
By-product coke ovens	41,864	——	62,700	50,073	75,000	86,000
Coal gas and bone carbonizing works	23,432	——	36,609	33,327	a31,500	a30,000
Total	65,296	a75,000	99,309	83,400	106,500	116,000
Per cent. from coke ovens	64.0		62.0	60.0	70.0	74.0

The figures for coke oven production are from actual reports by operating plants or from "Mineral Resources." Those for coal gas production are from "Mineral Resources" where obtainable, with allowance made for bone-black production.

(a) Estimated.

United States Ammonia Consumption, Expressed in Sulphate Equivalent (a)

(In tons of 2,000 lbs.)

Year	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910
Imports	8,411	13,486	18,146	16,777	16,667	15,288	9,182	32,669	34,274	40,192	63,178
Total consumption	36,011	43,765	54,270	58,650	71,331	80,584	84,182	132,000	121,874	149,192	179,179
Average price	$57.40	$55.16	$59.90	$62.10	$61.71	$62.92	$62.33	$61.93	$59.92	$56.04	$55.60

(a) The figures for consumption and price are for the calendar year, while those for imports are for the fiscal year ending June 30th.

World's Sulphate of Ammonia Production

(In metric tons of 2,204.6 lbs.)

Country	1903	1904	1905	1906	1907	1908	1909	1910
England	237,520	250,050	273,550	294,170	318,400	330,450	353,747	334,925
Germany	140,000	173,000	190,000	235,000	287,000	313,000	330,000	373,000
United States	38,000	49,600	59,250	68,000	90,120	79,500	96,600	105,143
France (b)	42,000	43,000	47,300	49,100	52,700	52,600	53,600	56,000
Belgium and Holland (b)	35,000	(a)39,000	24,200	30,000	(a)55,000	(d)35,000	(d)40,000	(d)43.000
Spain (b)	——	——	10,000	10,000	(c)12,000	——	12,000	9,000
Italy (b)	45,000	48,000	4,500	5,000	11,000	(d)80,000	12,000	12,000
Other countries (b)	——	——	40,500	40,000	65,000	——	(d)73,000	(d)79,000
Total	537,520	602,650	649.300	731,270	891,200	890,550	971,947	1,052,068

(a) Including Norway, Sweden and Denmark.
(b) Estimates from l'Engrais.
(c) Including Portugal.
(d) Estimates from Deutsche Ammoniak-Verkaufs Vereinigung, 1908-'09-'10.

COMMERCIAL FERTILIZER CONSUMPTION OF UNITED STATES IN 1910.

State	Quantity	Value	Lbs. per acre improved arm land	Value per acre improved farm land
Georgia	1,022,048	$16,819,000	167.0	$1.31
South Carolina	975,039	15,130,000	320.0	2.49
North Carolina	630,905	12,245,000	143.0	1.39
Alabama*	425,000	7,627,000	88.0	0.79
New York	375,000	9,375,000	——	——
Virginia	344,951	6,925,600	70.0	0.70
Pennsylvania*	300,000	6,756,000	47.0	0.53
Maryland	225,000	3,375,000	137.0	1.01
Ohio*	175,000	4,163,000	18.0	0.22
Florida	172,641	3,601,000	191.0	2.00
Indiana	151,856	3,695,492	18.0	0.22
Mississippi	132,776	2.699,000	30.0	0.30
Maine*	125,000	4,063,000	106.0	1.72
New Jersey	125,000	4.206,000	139.0	2.34
Arizona*	200	6,000	1.0	0.01
Arkansas*	25,000	596,000	6.0	0.07
California	36,660	2,132,000	6.0	0.19
Colorado*	2,000	58,000	0.93	0.01
Connecticut*	62,500	*1,875,000	——	——
Delaware*	23,000	*575,000	——	——
Idaho*	700	21,000	0.50	0.008
Illinois	32,000	571,000	2.0	0.02
Iowa*	3,500	107,000	0.24	0.004
Kansas*	2,400	73,000	0.16	0.002
Kentucky	58,000	1,348,000	8.0	0.09
Louisiana	88,396	2,001,000	34.0	0.38
Massachusetts*	65,000	1,931,000	112.0	1.66
Michigan	40,000	936,000	6.0	0.07
Minnesota*	2,100	63,000	0.21	0.003
Missouri	31,585	662,000	3.0	0.02
Montana	200	10,000	0.11	0.002
Nebraska	——	——	——	——
Nevada	160	8,000	0.43	0.01
New Hampshire*	50,000	510,000	108.0	0.55
New Mexico	480	24,000	0.65	0.02
North Dakota*	300	9,000	0.02	0.0004
Oklahoma*	8.000	26,000	0.91	0.001
Oregon	310	13,000	——	——
Rhode Island	10,300	309,000	115.0	1.74
South Dakota*	350	11,000	0.04	0.0006
Tennessee	58,612	1,212,000	11.0	0.11
Texas	34,000	589,000	3.0	0.02
Utah*	380	19,000	0.56	0.01
Vermont	22,000	570,000	27.0	0.35
Washington*	2,000	79,000	0.63	0.01
West Virginia	33,500	520,000	12.0	0.09
Wisconsin	2,500	122,000	0.42	0.01
Wyoming*	100	5,000	0.16	0.004
	5,875,449	$117,770,492		

The states using over 100,000 tons per year are arranged in order of their consumption, the remainder being arranged alphabetically. The values given are from the census reports and the quantities are from data supplied by the state agricultural authorities, except those marked * which are estimated.

WEEKLY QUOTATIONS PER 100 LBS. DOMESTIC SULPHATE OF AMMONIA, 25 PER CENT.

Oil, Paint and Drug Reporter of New York.

1909

Jan.	4	$2.89	July	5	$2.90
	11	2.91¼		12	2.87½
	18	2.91¼		19	2.87½
	26	2.93¼		26	2.87½
Feb.	1	3.01¼	Aug.	2	2.87½
	8	2.98¼		9	2.80
	15	2.98¼		16	2.75
	22	2.98¼		23	2.67½
March	5	2.98¼		30	2.67½
	8	2.98¼	Sept.	6	2.65
	15	2.98¼		13	2.65
	22	2.98¼		20	2.65
	29	2.98¼		27	2.65
April	5	2.98	Oct.	4	2.65
	12	2.98		11	2.65
	19	2.98¼		18	2.65
	26	2.95		25	2.65
May	3	2.95	Nov.	1	2.62½
	10	2.90		8	2.62½
	17	2.90		15	2.62½
	24	2.90		22	2.62½
	31	2.90		29	2.62½
June	7	2.90	Dec.	6	2.62½
	14	2.90		13	2.62½
	21	2.90		20	2.63¾
	28	2.90		27	2.67½
Average 6 months		2.904	Average 6 months		2.6995
			Average 12 months		2,802

WEEKLY QUOTATIONS.—(*Continued.*)

1910

Jan.	3	$2.68¾
	10	2.73¾
	17	2.72½
	24	2.73¾
	31	2.76¾
Feb.	7	2.75
	14	2.75
	21	.272½
	28	2.72½
March	7	2.82½
	14	2.82½
	21	2.85
	28	2.85
April	4	2.77½
	11	2.75
	18	2.75
	25	2.81¼
May	2	2.81¾
	9	2.82½
	16	2.82½
	23	.282½
	30	281¼
June	6	2.78¾
	13	2.78¾
	20	2.78¾
	27	2.78¾
Average 6 months		2.70
July	4	2.78¾
	11	2.78¾
	18	2.78¾
	25	2.78¾
Aug.	1	2.78¾
	8	2.78¾
	15	2.78¾
	22	2.80
	29	2.80
Sept.	5	2.85
	12	2.87½
	19	2.88¾
	26	2.88¾
Oct.	3	2.88¾
	10	2.88¾
	17	2.93¾
	24	2.93¾
	31	2.97½
Nov.	7	2.93¾
	14	2.93¾
	21	2.93¾
	28	2.93¾
Dec.	5	f2.96¼
	12	f2.96¼
	19	f2.96¼
	26	f2.96¼
Average 6 months		2.86
Average 12 months		2.78

f = future quotations, no spot offered.

WEEKLY QUOTATIONS.—(*Continued.*)

1911

Jan.	2	f\$2.96¼	April	3	3.15
	9	f2.96¼		10	3.15
	16	f2.96¼		17	3.07½
	23	f2.98¾		24	3.07½
	30	f2.98¾	May	1	3.07½
Feb.	6	f3.06¼		8	3.07½
	13	f3.03¾		15	3.07½
	20	3.12½		22	3.07½
	27	3.12½		29	3.07½
March	6	3.12½	June	5	3.05
	13	3.12½		12	3.05
	20	3.15		19	3.02½
	27	3.15		26	3.02½
			Average 6 months		3.066

f = future quotations, no spot offered.

THE PRESIDENT: Gentlemen, we will not discuss this paper until after all four of them are read. I will now call on Mr. C. G. Atwater to read his paper on "General Process of Manufacture of Sulphate."

MR. ATWATER: Mr. President and Gentlemen: I have some hesitation in presenting this paper because it is very largely the compilation of the work of others,, and also I might say that I do not see the name on the program of the man who had the most to do in getting up this symposium, on ammonium sulphate, viz: Captain W. E. McKay. This paper I presume fills a certain place in the transactions as recording progress and making the transactions take on to a certain extent the character of a reference book, which I think adds to their value. I also think, considering the length, of the paper it will be a relief to you to hear that I am not going to read it all. There has been a great deal of progress made in the manufacture of sulphate of ammonia in the last

few years. We are probably all familiar with the old way of making the sulphate of ammonia. I will touch on that later on. But recently, we have seen the process advance from the recovery by the use of water as a washing agent to the recovery by the use of sulphuric acid direct from the gas, and then we have gone further to the newest processes in which other washing fluids are used, and the sulphur in the gas itself supplies the sulphuric acid for the manufacture of the sulphate of ammonia. That has been a great advance, and I think it is highly appropriate that this Association should take some note of it in its transactions. In this paper I have taken up the different plants, commencing with the simpler ones and proceeding to the more complicated ones.

PLANTS FOR SULPHATE OF AMMONIA.

It is the object of this paper to describe briefly the types of apparatus used in making sulphate of ammonia, in so far as information concerning them is at hand.

It should be stated beforehand that part of the illustrations and part of the text of this paper have been used by the writer in an article on the same subject in "The Mineral Industry" for 1907, and later revised with the addition of descriptions of the "direct" processes for the American Fertilizer Handbook, in 1910.

The manufacture of sulphate of ammonia on a moderately large scale in this country may be said to have begun in 1893 with the erection of by-product coke oven plants. Previous to this it was made at various coal-gas works and elsewhere, but the plants were necessarily of small capacity, as the supply of ammonia was limited to the works output. These conditions have, in a great measure been changed. A number of by-product coke oven plants have been built, many of which are successfully converting their ammonia into sulphate.

As in other lines of manufacture, we may expect to find the most economical production in the plants that operate on a large scale. This is particularly true of a product like sulphate of ammonia, the making of which involves a certain

amount of manual labor which may be cheapened or eliminated in large installations. It is partly for this reason that the present output of sulphate in this country comes almost entirely from by-product ovens. These plants are by far the largest individual producers of ammonia, and therefore afford the opportunity for the making of sulphate in quantity. The usual recovery of sulphate from coal is about 1 per cent. of the weight of the coal carbonized, so that for the production of five tons of sulphate per day 500 tons of coal must be carbonized. There are but few coal-gas plants of this daily capacity in the United States, but, on the other hand, most of the by-product oven plants exceed it. In England coal-gas works of such capacity are more frequent, and those of smaller size are comparatively closer together, so that opportunity has been afforded for the establishment of ammonium sulphate plants that manufacture on a large scale, in some cases drawing their supply of liquor from several sources.

Both England and Germany, being larger producers of sulphate of ammonia, have lead us in the design of apparatus for the purpose, therefore much that follows is from the practice of these countries. Germany, in particular, has developed what is known as the "direct" method of producing sulphate from coke oven gas, which process seems likely to reduce the cost of plant and of operation.

The original method of making sulphate of ammonia was by running sulphuric acid directly into the crude ammonia liquor. and evaporating until the salt crystallized out. This method wasted all the "fixed" ammonia and produced an impure and dirty salt. Happily it has passed out of use, in this country, the only relic of its existence being the archaic style of expressing the strength of ammonia liquor in ounces of sulphuric acid, in place of the actual per cent. of NH_3.

Chemistry of the Process.

The chemistry of ammonium sulphate has been frequently and adequately described elsewhere,[1] so that it will suffice to

[1] See Lunge. "Coal Tar and Ammonia;" Cammille Vincent. "Ammonia and Its Compounds"; R. Arnold, "Ammonia and Ammonia Compounds"; F. Schniewind "The Mineral Industry", Vol. X. p. 149.

give only an outline here. In the methods hitherto employed the coal gas or coke oven gas has been washed with water, and the ammonia thus obtained in aqueous solution of from 0.5 per cent. to 2 per cent. strength has been treated by distillation. In the newer "direct" process, the ammonia in the gas is combined directly with sulphuric acid to form the sulphate. Leaving the discussion of the later method for the present, we will treat first of the older and still generally followed process.

The crude liquor from the ammonia washers, as described above, is the raw material of the sulphate of ammonia plant. Chemically speaking, it is a complex compound, containing ammonia in various forms. Those that part with their ammonia on boiling, as the carbonate and sulphide, are known as "free" ammonia, while those that do not decompose at this temperature, as the chloride, sulphate, sulphite, thiosulphate and ferrocyanide, are known as "fixed" ammonia.

The crude liquor is passed through a still, encountering a current of live steam, and is thus deprived of its free ammonia. The liquor containing the fixed ammonia is then mixed with a certain proportion of milk of lime (or other alkali), the effect being to free the fixed ammonia, which is then driven off by steam distillation, as before. The reactions that render the fixed ammonia free may be typified by that for ammonium chloride, which follows:

$$Ca(OH)_2 + 2(NH_4)Cl = CaCl_2 + 2H_2O + 2NH_3.$$

The gaseous ammonia, mixed with steam and the volatile impurities, as carbonic acid, hydrogen sulphide and tarry vapors, pass from the still to the condenser or separator, where a certain amount of water is removed, and are then led to the saturator. Here they are brought into intimate contact with dilute sulphuric acid and chemical combination ensues which may be expressed by the following equation:

$$2NH_3 + H_2SO_4 = (NH_4)_2SO_4.$$

This reaction is attended with considerable heat. The sulphate of ammonia forms as small crystals and settles to the bottom, and the incondensable gases are usually conducted to a smoke stack in operation, if one is at hand, or disposed of

in some other manner. In the most modern plants the waste gases are chemically treated and rendered inocuous before being allowed to escape into the air.

Nature of Plant Required.

The essential parts of the apparatus are therefore a still, in which the ammonia is driven off, and a saturator, in which it is combined with acid. The still consists of the section for free ammonia distillation, the intermediate liming vessel, and the section for the distillation of the fixed ammonia set free by the action of the lime. This part of the apparatus is almost invariably made of cast iron. The stills are usually built up of separate sections fastened one above another and provided with a system of partitions, connecting passages and sealing hoods, so that the ammonia liquor entering at the top of the column and flowing gradually downward is exposed to the action of the steam which enters below and passes upward, bubbling through the successive seals. This is the general plan, subject to many individual variations in design.

Accessory to the still are the pumps and tanks for crude liquor supply, the apparatus for slacking, measuring and injecting the lime, and the necessary steam piping, water piping, sewer connection for spent liquor from the still etc. Frequently provision is made for a condenser which strengthens the ammonia leaving the still by removing some of the water vapor, and for a heater which permits the preheating of the crude feed liquor by the heat from the outgoing spent liquor or the waste gases. In some cases the concentration of the ammonia leaving the still is effected in whole or in part by the cold feed liquor.

The saturator consists of a tank or vessel of wood or iron, lined and protected with sheet lead to prevent corrosion by the acid. The ammonia vapor is led beneath the surface of the acid in the saturator by a dip pipe or bell, also lead protected, usually so arranged as to compel all the vapors to bubble through the acid and allowing all those that are not absorbed to be carried away by a special connection, so that they shall not escape into the air. Accessory to the saturator are the tanks

and pumps for supplying and handling acid and mother liquor and the appliances for removing the sulphate from the saturator, draining it, drying it and handling it to storage. Provision is also made for the supply of steam necessary to run the still and pumps, and where conveying and other machinery is adopted, power is also needed.

In the following descriptions of various plants the simpler ones will be taken up first, and those of more complicated character next in order.

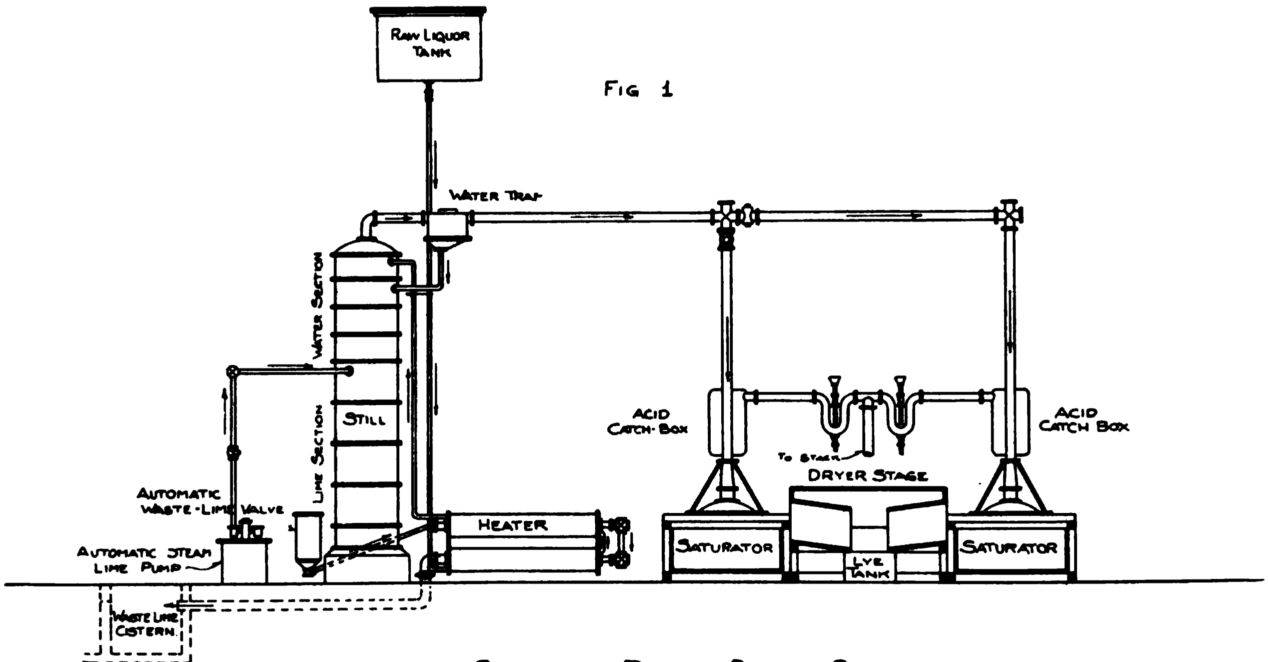
Bamag System.

Fig. 1 shows the "Bamag" system (Berlin-Anhaltische Maschinenbau-Actien-Gesellschaft) built in the United States by Bartlett, Hayward & Co. This plant consists of an ammonia still with an overhead wrought iron crude liquor feed tank with wooden float and scale, automatic steam lime pump with agitator tank, automatic waste liquor valve, water trap, crude liquor heater, two saturators with lead-covered wooden acid boxes, lead bells and lead-covered acid catch boxes, lead-covered wooden drying stage and mother liquor tank, as shown. There are also an all-iron hand pump, a steel storage tank for acid, an air compressor for lime agitation and a centrifugal dryer for sulphate, not shown in the drawing.

The crude liquor passes by gravity to the heater, where it is heated by the waste liquor from the still, the hot feed liquor passing then to the upper part of the still, where the volatile ammonia is driven off. The lime is pumped into the intermediate section of the still and is thoroughly mixed with the liquor as it passes downward through the lime sections. The waste liquor leaves the still by the automatic waste valve. This waste, it is stated, should not contain more than five parts of ammonia in 100,000.

A water trap or separator placed close to the still serves to remove the condensed water from the ammonia gases, the condensate draining back to the still. The ammonia gases then enter the saturator through the lead bell. The unabsorbed gases pass from the bell to the acid catch box where the liquor acid is retained the waste gases are sent to the stack.

Fig 1

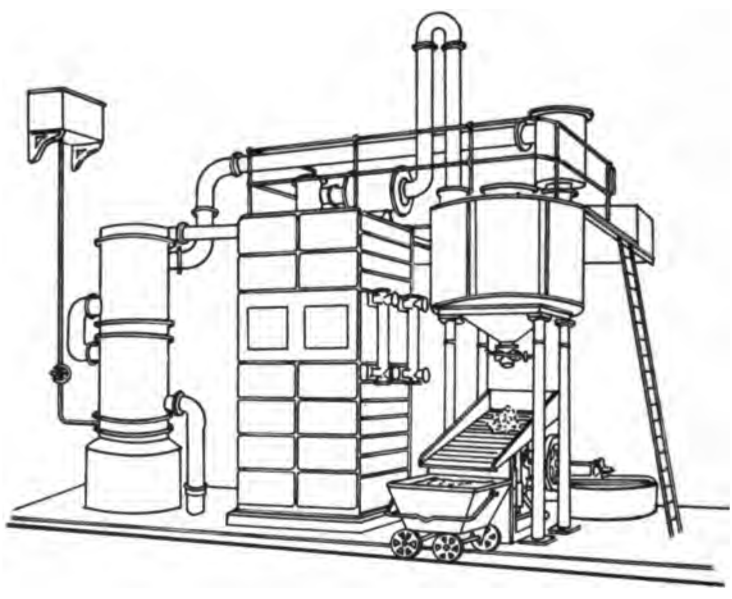


AMMONIA SULPHATE PLANT. BAMAG SYSTEM.

The formation of sulphate in the saturator is greatest under the lead bell, whence it must be removed by a wooden rake, and dipped out by hand with a copper ladle when the acid is nearly neutralized. The sulphate thus removed is then drained on the drying stage and the drainings run into the mother liquor tank. The sulphate may be then handled to the centrifugal dryer and thence to storage.

In this type of plant the still is operated continuously and

FIG. 2.



WALKER'S SULPHATE OF AMMONIA PLANT
WITH SQUARE STILL AND SELF-DISCHARGING SATURATOR.

the saturators alternately, one being saturated while the other is having the sulphate dipped out and the acid bath prepared for another run. Its operation also involves handling the sulphate by manual labor from the saturator to the drain board, thence by wheelbarrow to the centrifugal dryer, and again from the dryer to the storage bin.

Walker Plant.

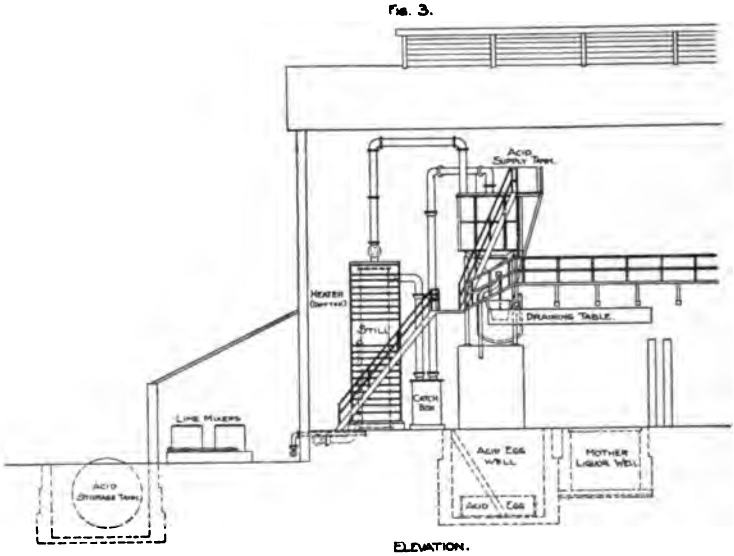
An arrangement eliminating some of the manual labor is shown in the following plant, which is by C. & W. Walker, London, England. (See Fig. 2.) The still is of the square type, the free still being the upper sections, the liming chamber the intermediate section, and the fixed still the lower sections of the column. The crude liquor flows from an overhead supply tank through the tubes of a vertical tubular heater and absorbs heat from the waste gases coming from the saturator. The tubes of the heater are provided with expansion joints at either end. The lime is mixed with water in a mixing tank provided with mechanical agitators driven from the steam pump, which also injects the lime milk into the still.

In the lower section of the still and also in the liming chamber there are perforated steam coils, supplied with steam through a reducing valve which maintains the desired amount of pressure. The lower coil serves for the steam admission to the still, while that in the liming chamber is primarily to agitate the lime and cause it to mix properly with the liquor. Special emphasis is laid on the ease with which the still can be cleaned and upon the freedom from stoppages from light tar carried in with the liquor by virtue of the size and arrangement of the overflow connections possible in a square still.

The ammoniacal gases escaping from the still pass through a baffle box where the condensed water is removed, thence through an inverted U-pipe to the saturator, which is of special type. It is cylindrical in form and has a flat top and a conical bottom, the whole being supported on columns above a drainage board. The shell of the saturator is of cast iron and it is lined throughout with lead. The sides are of segmental plates, between the flanges of which the lead sheets are inserted and firmly held, the lead being afterward burned together to insure a thoroughly tight joint. The same style of joint is used in the bottom and top. The ammonia inlet and the waste gas outlet connections are made to the top of the saturator and are of the usual form. In the center of the

top is a clean-out opening of large enough diameter to permit a man to enter the saturator to make repairs, and from this opening depends a lead curtain pipe which dips into the acid in the saturator, thus allowing access at any time. The discharge of the saturator, which is facilitated by the conical form of the bottom, takes place through a Howell patent discharge valve made of specially prepared copper. This valve consists of a casing in which is mounted a plunger capable of backward and forward motion by means of a lever. The move

Fig. 3.



Elevation.

Sulphate of Ammonia Plant by John H. Darby.

ment of the plunger serves to clear the passages of any incrustation or deposited sulphate.

The discharged sulphate and mother liquor are received on the drainage board and the liquor is drained off to a cistern, while the sulphate when sufficiently dry may be handled to a centrifugal dryer. Or, it is stated, the saturator may be placed directly over the centrifugal dryer if desired.

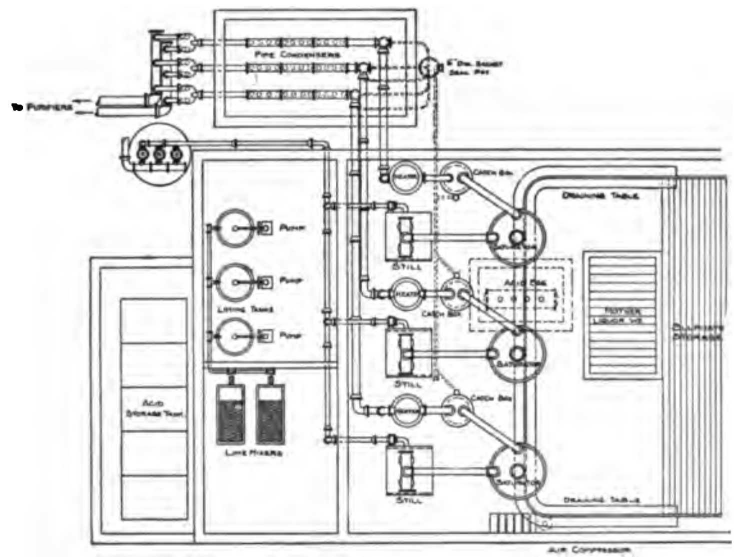
In addition to the saving of labor in handling the sulphate which this form of saturator makes possible, an additional advantage is claimed for the durability of the lead lining, which

is not bruised or abraded by the action of the dipping ladles. The waste liquor from a still of this type should, it is stated, contain less than 0.006 per cent. NH_3, and this with the consumption of 8 cwt. of good coal per ton of sulphate produced from crude liquor of 5.25° Twaddell.

Darby Plant.

Figs. 3 and 4 show in plan and elevation a sulphate of ammonia plant typical of those erected by John H. Darby, Brymbo, Wales, in connection with by-product coke oven plants. This design shows a step further in the direction of saving labor, in that the sulphate from several stills is handled

Fig. 4.



Ground Plan.
Sulphate of Ammonia Plant by John H. Darby.

mechanically from the saturators to storage without any hand labor whatever. The plant shown is said to be capable of dealing with 250 to 270 tons of coke oven liquor per 24 hours[1] and is erected in three independent units, any of which may be laid off without interfering with the others. Each unit consists of a still, a heater and a saturator.

[1] Equivalent to 10 to 16 tons of sulphate with liquor of 1.24 to 1.5 per cent. NH_3.

The liquor is fed by gravity through the heater, where it is preheated to about 80° C. by the waste gases from the saturator. The still is square in section and of the combined free and fixed type, with a liming chamber about the middle of the column. Each compartment has four hoods, which are accessible by removing the side plates. The overflows from one compartment of the still to another are particularly liable to block up, and to avoid having to expose the whole compartment of the still by removing the side plate, the overflows are made exterior to the still and may be cleaned by removing a small cover plate.

The limy effluent liquor from the still is sealed in seal pots of sufficient depth to maintain a pressure of about 5 to 8 pounds per square inch in the stills, and then flows to settling tanks to clarify and cool.

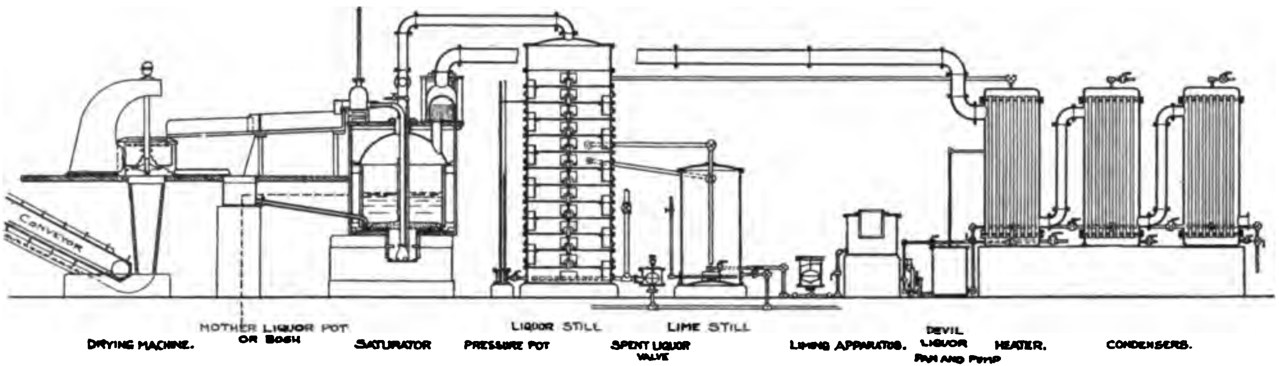
The ammonia vapor is delivered to saturators of the self-discharging type, elevated sufficiently to discharge the salt into buckets running on trolleys around the salt store. A continuous table catches the drainage from the buckets and delivers it to the mother liquor tanks, whence it flows into the mother liquor well below the floor. The same well collects the drainage from the sulphate store. The mother liquor flows by gravity from the well into an egg and is blown by compressed air into an overhead tank for feeding the saturators. The fresh acid is blown by compressed air from the large acid storage tank outside the house to the elevated acid and mother liquor mixing tank, where the bath is prepared before flushing it into the saturators.

The foul gases from the saturators pass through the catch pots where some of the watery vapor is intercepted, and thence through coolers (where the ingoing liquor is heated) to condensers. The uncondensed gases chiefly sulphuretted hydrogen, are passed through a Claus kiln to recover the sulphur, and finally through oxide purifier beds of the heaped up type as a safeguard.

Wilton Plant.

The general arrangement of the plant is shown in Fig. 5.

Fig. 5.



Wilton's Sulphate of Ammonia Plant.

The liquor is fed into preheaters and from there to the stills, which it enters at a temperature over 187° F., at which point all volatile ammonia is freed. These preheaters are tubular, made entirely of cast iron, with specially constructed joints where the tubes fit into the tube sheets, to insure against leaks caused by expansion or contraction. The preheating is done by the exhaust gases from the saturator, these gases being almost entirely condensed by the time they leave the last heater. The condensation or "devil liquor" is frequently tested for

Fig. 6.—Wilton's ammoniacal liquor still. Bubbling weir.

ammonia, and if it shows any appreciable amount it is saved and put back through the still with the gas liquor.

The construction of the still sections is shown in Fig. 6 in detail, the salient point being its accessibility for cleaning. Each section has but one bubbling weir which can be lifted up and pulled out of the side door, leaving the whole section clear to be steamed or scraped, without the necessity of taking the still down section by section, as is necessary with most designs. The overflows are easily reached through smaller hand holes in the sides, as also shown in the cut.

The saturator, like that shown in the Walker plant already described, is completely enclosed. The connection for inlet and outlet gas is made at the top, a manhole also being provided there for access in making repairs.

The most interesting feature of this still, however, is the method adopted for removing the salt. This is done by a steam ejector or syphon. The bottom of the saturator is perfectly flat, except for a small well in the center, in which the ejector stands. The ammonia vapor enters the saturator by two pipes, which come vertically through the top and enter the center of two crescent shaped perforated pipes which surround the well. The perforations are arranged so that the vapor shoots downward and towards the well, blowing all the salt to the well, and at the same time thoroughly mixing and saturating the acid bath. The mother liquor comes in from the mother liquor pot and falls to the bottom of the saturator just back of the perforated pipes. This mother liquor pot is shown on top of the brick pier to the left of the saturator, and communicates with the latter by an inclined pipe.

The operation of the saturator is the same as for any other type of continuous saturator. The bath is kept at about 32°-33° Bé by a constant stream of acid flowing in and the ejector may be kept going constantly throwing out salt or the salt may be allowed to fill the well and up to the spray pipes and the ejector may be used intermittantly. A bell and vent pipe are provided toward the discharge end of the ejector pipe to carry off the steam so that it does not escape in the house. After being ejected onto the drainboard, the salt is handled in the usual way through a centrifugal dryer. The liquor from the drainboard and dryer runs directly into the mother liquor pot and from there into the saturator. The liquor level in the saturator is shown by the corresponding level in the liquor pot, or bosh as it is sometimes called, on the other side.

The advantage gained by the use of the ejector to handle the salt to the drainage boxes is very great, as it eliminates all hand labor to this point. It is stated by the makers that one man can operate a plant producing 10 tons of dried

sulphate per day. From the drainage board it is only necessary to rake the salt into the centrifugal, whence it is dumped into the conveyor below. This type of plant has met with much success.

The processes described so far have been of the type generally used, in which water is the liquid by which ammonia is absorbed from the coal-gas. Two processes have appeared recently in which this step has been eliminated, in part or entirely, and the absorbtion accomplished by the sulphuric acid itself. Both of these processes are of German origin, and are, respectively, that of Heinrich Koppers and that put forward by Dr. C. Otto & Co.

It is hardly fair, however, to discuss these methods without some reference to the work of Brunk, who in 1903 obtained directly crystallized sulphate by passing coke oven gas through sulphuric acid, using two saturators in series. This attempt failed, because the gas contained tar, which contaminated the sulphate and complicated the operation in other ways. The success of the later attempts rests on the ability to entirely remove the tar first. This is accomplished in the Koppers plant by reducing the temperature of the gas sufficiently to remove the tar by a P. & A. scrubber, the gas being then reheated before going to the saturator. In the Otto plant, the tar is removed while the gas is still hot by the use of a jet of tar sprayed into the gas, the effect being to condense the tar mist into a liquid form that is easily drained off. Both methods are in regular operation at a number of plants and both produce salt of an excellent quality.

Koppers Ammonia Recovery System.

The accompanying illustration Fig. 7 shows a diagrammatic representation of this system. The hot gas from the ovens enters the cooler, (B) which is of the multitubular type, where the temperature is reduced to about 90° F. The gas is then drawn by an exhauster (C) by which it is delivered to the tar extractor (D). After having been freed from the tar the gas is passed through a re-heater (A) where in passing between the tubes, it becomes heated to about 160° F. The

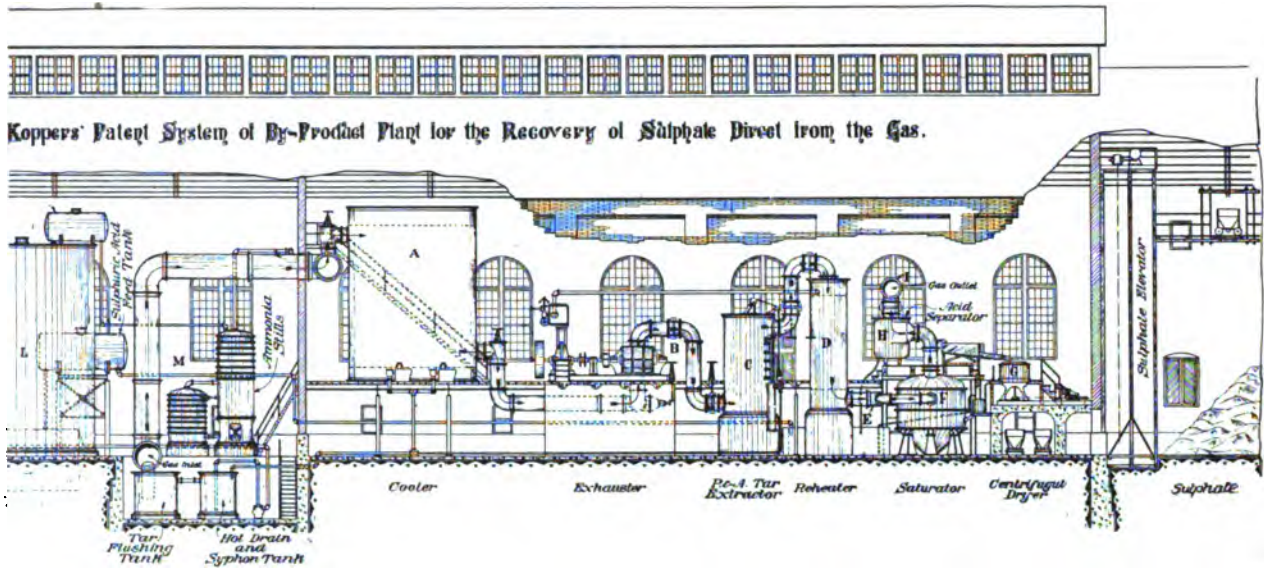

Koppers' Patent System of By-Product Plant for the Recovery of Sulphate Direct from the Gas.
A
B
C
D
E
F
G
H
L
M
Sulphuric Acid Feed Tank
Ammonia Stills
Gas Inlet
Gas Outlet
Acid Separator
Sulphate Elevator
Tar Flushing Tank
Hot Drain and Syphon Tank
Cooler
Exhauster
P. & A. Tar Extractor
Reheater
Saturator
Centrifugal Dryer
Sulphate

Fig. 7.

heated gas is then conducted through the main (F) to the acid saturator (E), in which the ammonia in the gas is extracted by direct contact with the acid, and is recovered in the form of sulphate. The saturator is of the totally enclosed type, and the salt is continuously removed therefrom by means of an air injector. The salt is delivered to a collecting table from whence it is run off, together with the accompanying mother liquor into a centrifugal dryer (L) in the usual way.

The gas passes out of the saturator and through an acid separator (H) into the main (K), by which it is conducted back to the ovens, or if it is to be distributed to domestic consumers, it passes through the usual purifiers, meter, and storage holder.

The products of condensation which are extracted in the cooling and tar eliminating operations, are drawn off from the several apparatus and are conveyed into a separating tank (H), where the tar and ammoniacal liquor separate, according to their specific gravities. The tar flows into the storage tank (I), and the gas liquor into the storage tank (J). The liquor is pumped to the ammonia still (G), where the ammonia is driven off by means of steam and lime in the usual way. The vapors of distillation are conducted from the still, and are delivered into the main at the inlet of the cooler, where they mix with the gas, and are finally absorbed in the saturator.

Regarding the operation of this saturator it is stated that the saturator liquor is maintained at from 3 to 5 per cent. of acid only, and as this is kept at a low temperature, the organic constituents of the gas are not in the least affected. The gas on leaving the saturator contains no trace of acid and therefore there need be no fear of any corrosion taking place in the gas mains.

The usual temperature at which sulphate is produced in the ordinary open saturator is from 220° to 240° F., and as the salt obtained in this way is accompanied by free acid, trouble is experienced in shipping owing to the action of the acid on

the bags. The new system, it is claimed, renders it possible to produce a neutral salt at a temperature as low as 100° to 125° F, the chemical affinity between the NH_3 and the H_2SO_4 being so great within this range. Also, the regulation of the temperature of the acid bath may be made to govern the amount of condensation that takes place there.

The salt is stated to be excellent in quality, white in color, and without the slightest odor of tar. Its percentage of NH_3 is as high or higher than salt made in the ordinary way.

Plants of this type are in operation at Gary, Indiana, Woodward, Alabama and at Sault Ste. Marie, as well as at a number of foreign plants. The process is being introduced into this country by Mr. Koppers, ~~of~~ Joliet, Ill.

Dr. C. Otto and Co's. Ammonia Recovery Process.

This method may be called the direct process. It is being introduced into this country by the United Coke and Gas Company, New York. It is in actual use at a number of English and German works.

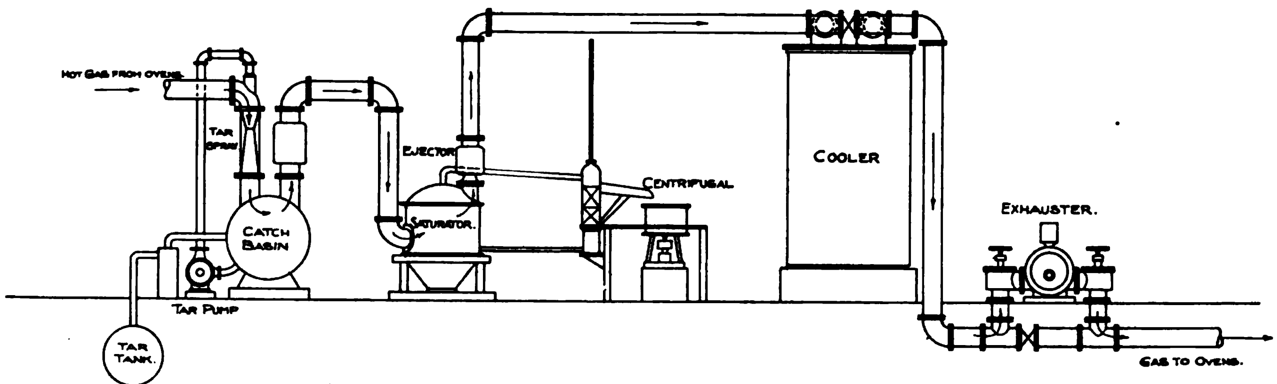
The accompanying illustration Fig. 8 shows the general arrangement of the Otto plant.

The hot gas coming from the ovens encounters a tar spray, fed by the tar pump as indicated. A very intimate mixture of the tar and gas takes place, and the tar separates entirely from the gas in the catch basin immediately succeeding the tar spray. The tar produced runs off from the catch basin to the tar storage tank. After the tar separation the hot gas containing all the water and ammonia vapors is conducted to a closed saturator containing the sulphuric acid.

Here the ammonia is precipitated in the form of sulphate of ammonia, and is lifted from the saturator to a draining table by an ejector, as indicated on the drawing. It then passes to the centrifugal dryer, thence to the storage bin. The mother liquor from the draining table and the centrifugal returns directly to the saturator.

After the gas has passed the saturator it is cooled and freed from water in water coolers to fit it for subsequent use.

Fig. 8.

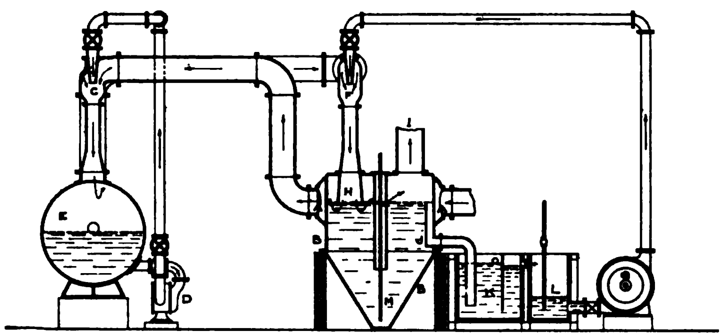


Dr. C. Otto & Co's Ammonia Recovery Process.

The gas is moved at first by the tar spray blowers as far as the saturators, and in the subsequent part of the plant by the exhausters, which draw the gas through the saturators and the coolers and then deliver it to the benzol plant, thence to the coke ovens and other points of consumption.

The advantages of the direct method are evident. Both the equipment and the operation of a plant are considerably simplified. There are no ammonia washers, hence there is no water consumption for gas washing. There are no ammonia stills,

FIG. 9.



DR. C. OTTO & CO.'S AMMONIA PLANT.
ACCORDING TO A RECENT PATENT.

hence there is no consumption of steam and lime, and no spent liquor and waste lime to take care of. These simplifications result in a considerable saving in the cost of operation.

A modification of the original Otto apparatus is described in a recent patent. The illustration Fig. 9 shows the arrangement of the tar spray and saturator more in detail than the previous drawing.

The crude hot gas which first of all circulates in an envelope A is used for reheating the saturator B. By the injector C, which a pump D feeds with hot tar, it is relieved of the tar, which is received in the collector E. While in existing plants the gas is led by two distributing pipes into the bottom of the acid contained in a saturator of the same external form as in

the diagram, the Otto system is to make the hot and tar-relieved gas pass through the injector F, which is supplied with liquid acid by a pump G. A more complete reaction would thus be assured than in the large saturation vessels provided with the ordinary means for increasing the contact of gas and liquor. To avoid the acid being carried off and to complete the washing, the end of the injector dips lightly into the saturating bath H. After this last bubbling through, the gas leaves (at I) practically free from ammonia, and passes into a cooler in order to have its steam extracted. The mother liquor is run out by the overflow J into a separator K, where the small amount of light tar which was able to float on the bath is retained. This mother liquor is continuously retaken by the pump G from the vat L. An ejector M lifts the salt deposited in the saturator G into a dryer.

Wilton's Modified Sulphate of Ammonia Plant.

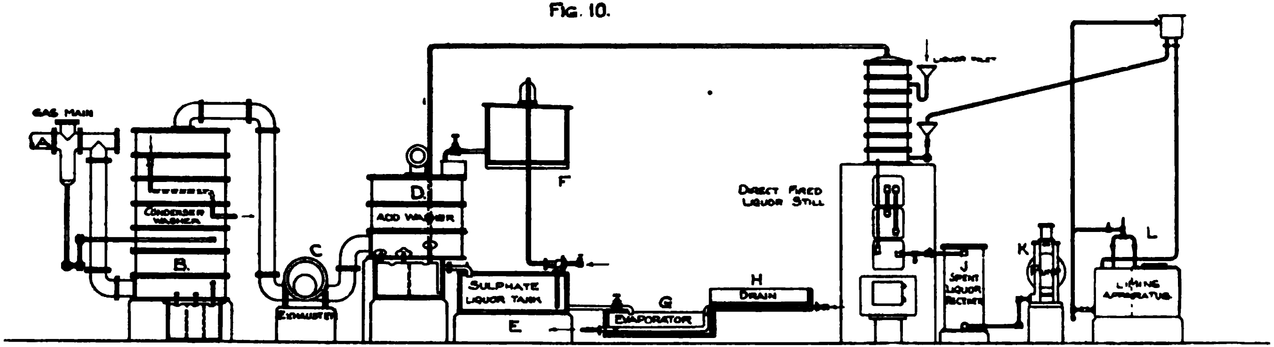
A modification of the Wilton plant already described has been put out, the particular feature being that it adapts the Koppers arrangement to the purposes of a small or moderate gas plant. The general arrangement is as shown in Fig. 10.

The gas from the hydraulic main passes through a condenser and then to an exhauster, going then direct to an acid washer or saturator. The exit gases from the saturator are lead to the purifiers. The liquor condensed in cooling the gas is distilled in a small direct-fired still provided with suitable liming apparatus, pumps, etc., and the ammonia from the still returns to the saturator box to be absorbed by the acid along with that obtained from the gas. The sulphate appears to be drawn out of the saturator by gravity to a tank along side the saturator, and the mother liquor is drained off, the excess being evaporated in an evaporating pan.

The Burkheiser Process.

This process is designed so as to recover ammonia as sulphite or as sulphate from coal gas. It employs the ordinary methods of cooling the gas and removing the tar, but then in

Fig. 10.



WILTON'S MODIFIED SULPHATE OF AMMONIA PLANT.

place of scrubbing it for ammonia passes it through purifiers charged with a special oxide which removes the sulphuretted hydrogen only. Thence the gas is led to a saturating box, where the ammonia is absorbed by an acid water solution prepared by washing the air with which a sulphur-fouled box has been regenerated. The ammonia removed as liquor by the ordinary condensation process before the purifier is passed through an ammonia still and the vapor is passed through the purifier with the gas. After the saturator above mentioned the exit gases are passed through a supplementary ammonia scrubber, where the last traces of ammonia are removed by washing with acid solution.

The whole process operates in a continuous cycle or series of cycles, producing a finished dry salt and a clean gas. The advantages claimed are:

(1) Production of ammonia salts and purification in one complete and simple process.

(2) Avoids purchase of acid by using the sulphur in the coal.

(3) Cyanogen compounds are transformed into the more valuable ammonia, increasing the ammonia yield by 8-10 per cent.

(4) Reduction of cost of plant and room required in buildings.

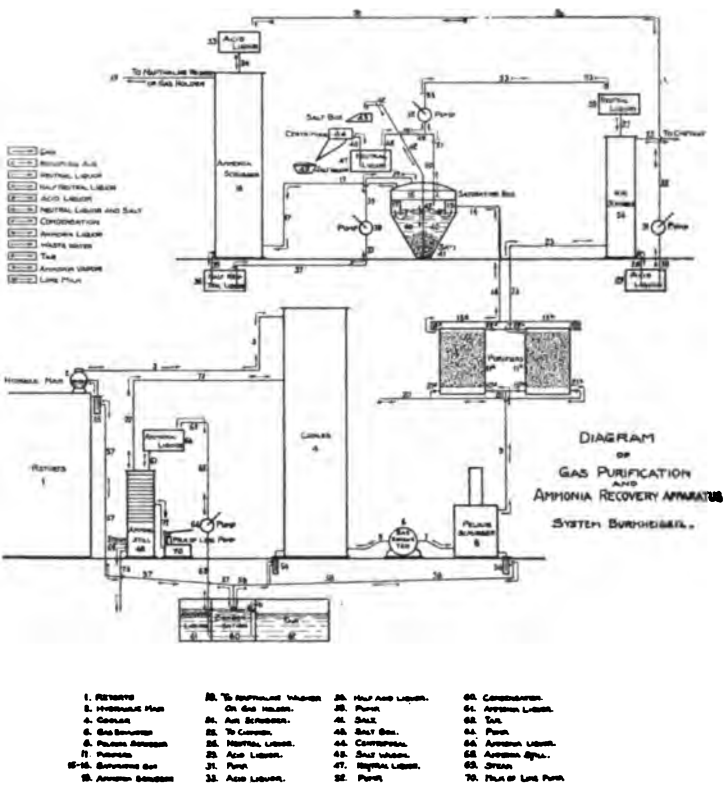
The oxide used in the purifiers is specially prepared, the preparation, as stated, consisting of heating ordinary bog ore of rather large size to a point sufficiently above 100° C to remove part of the chemically combined water, the oxide turning first a yellow color and then a deep red when the proper degree of heating is obtained.

The oxide so prepared is said to be extraordinarily efficient in removing H_2S so that a gas speed of 8 inches per second is admissible. Furthermore, a depth of 6 to 10 feet of the mass can be resorted to, because of the large grains and open character. This saves room in the purifying apparatus.

The regeneration of the oxide takes place in the purifier,

there being two boxes receiving alternately gas and air. The ordinary regeneration to sulphur must be carried on so energetically as to form sulphurous acid. The heat so produced renders a special construction of the boxes necessary, and this heat is transferred to the adjoining box in which the gas is be-

FIG. 11.



ing purified. As it is stated, no condensation of moisture is allowable in the purifier, as it would lessen the activity of the oxide, hence the maintenance of a higher temperature in the gas than that desired in the coolers is advantageous. This is obtained by the transfer of heat from the adjoining purifier.

The following description of the operation refers to the

diagram Figure 11. The process is supposed to be applicable to coke ovens, although a retort gas plant is here designated.

Description of Burkheiser Process.

The gas comes from the retorts at 1, through the hydraulic main 2, and pipe 3 to the cooler and is here cooled to the proper temperature for separating the tar, goes through the pipe 5 to the gas exhauster 6, through the pipe 7 into Pelouze scrubber 8 and is here entirely freed from tar. The condensation from the cooler 4 goes to 54 and from there through the pipes 58 and 59 to the pit 60, where the ammonia liquor and tar separate themselves in accordance with their specific gravities in the pits 61 and 62. The condensation from the Pelouze is also led to these three pits through the pipe 58 and 59. The ammonia liquor in 61 which contains also considerable of the sulphuretted hydrogen and cyanogen important to this process is raised by the pump 64 through the pipes 63-65 to the overhead tank 66, and from here passes through the pipe 67 to the ammonia still 68. Milk of lime is supplied by the lime pump 70 and the pipe 71 in order to free the fixed ammonia, and steam enters the still through the pipe 69. The vapors from the still are led through the pipe 72 directly into the cooler 4. The hot vapors from the still encounter the cooler gas in the cooling column and the condensation is drained away, an effect that is possibly aided by the rapid circulation due to the difference in temperatures.

By this arrangement all of the sulphuretted hydrogen, cyanogen and ammonia are delivered to the Burkheiser apparatus proper which immediately follows the Pelouze. At first sight it would appear that the condensates would circulate continuously through the cooler and distilling column, and that their quantity would constantly increase. This, however, is far from being the case as a certain equilibrium is soon arrived at so that the evaporation of only 25 per cent. more water than that naturally condensed from the gas is necessary. The gas from the Pelouze containing all the ammonia cyanogen and sulphuretted hydrogen passes through the pipe 9, past the

closed valve 10-B and through the open valve 10-A into the Burkheiser purifier 11-A, which is filled with Burkheiser purifying oxide. This removes all of the sulphuretted hydrogen and also a large part of its cyanogen, and the valve 22-A being closed, the gas leaves the purifier by the valve 12-A and the pipes 13-A and 14, reaches chamber 15 of the saturating box, here parts with the largest portion of its ammonia and leaves the chamber 16 by the pipe 17, passing to the ammonia scrubber 18. The gas leaves the scrubber entirely clean and ready for use. The pipe 19 is provided to connect with a naphthalene scrubber if desired.

After a fixed period has elapsed, say 1, 2, or 3 times in twenty-four hours, the purifier in use becomes saturated with sulphuretted hydrogen. The valve 1 A is closed and the valve 10-B opened so that the gas is turned into purifier 11-B and led through the valve 12-B to the pipe 13-B, from here the process goes on as before. The fouled purifier, the oxide in which is saturated with sulphuretted hydrogen now receives a carefully regulated current of air by which the sulphur compounds removed from the gas are so strongly oxidized that they form sulphurous acid.

Assume that 11-B is the purifier that has up to now received the gas. The air current passes by the pipe 20 and an open valve 21-B into the purifier 11-B the sulphurous acid there formed passes out of the open valve 22-B, the valve 12-B being closed, passes through the pipe 23 to the air scrubber 24 and there gives up all its sulphurous acid to the liquor introduced from the tank 26 by the pipe 27. The acid solution drained to the tank 29 is lifted by the pump 31, through the pipe 32 to the overhead holder 33, flows from there through the pipe 34 to the ammonia scrubber, here absorbs the rest of the ammonia that remains in the gas and flows as half neutral liquor through the pipe 35 to the collecting tank 36, passes through pipe 37 to the pump 38, and is delivered to pipe 39 to the saturating box where it is entirely saturated with ammonia, becoming fully neutral. This neutral solution is drawn through the pipe 50, and an open valve 51, to the pump 52,

from there by the pipe 53, to the tank 26, where through pipe 27 it again goes to the acid washer 24 to be once more saturated with sulphurous acid and to flow as acid solution through 28 to the tank 29. This acid solution has again a strong affinity for ammonia, therefore it passes through pipe 32 and tank 33, once more to the ammonia scrubber 18 and there absorbs ammonia. As soon as the saturation point is reached the salt crystallizes out and deposits in the saturating box. This salt is lifted by the ejector 42 to the salt box 43, and from there to the centrifugal 44 where it is dried and comes in that condition to the salt wagon ready to ship. The mother liquor draining from 44 passes through the pipe 46 to the liquor washer 47, and is there placed in circulation again by the pump 52 which delivers it to the tank 26 to pass again through the acid washer, etc., as before.

As may be seen the absorbtion of the ammonia is accomplished to some extent by the ammonia scrubber 18, but principally by the saturating box. In this way the loss of ammonia remaining in the exit gas from the saturating box is avoided on the one hand and the formation of salt in the ammonia scrubber on the other. The salt formation takes place in the saturating box.

It is claimed that the use of lead linings for the saturation apparatus is entirely unnecessary.

The ammonia salt obtained is stated to be about 75 per cent. sulphate and 25 per cent. sulphite, and tests 25 to 25.5 per cent. NH_3. It is pure white in color and contains no free acid, always having a slightly alkaline reaction.

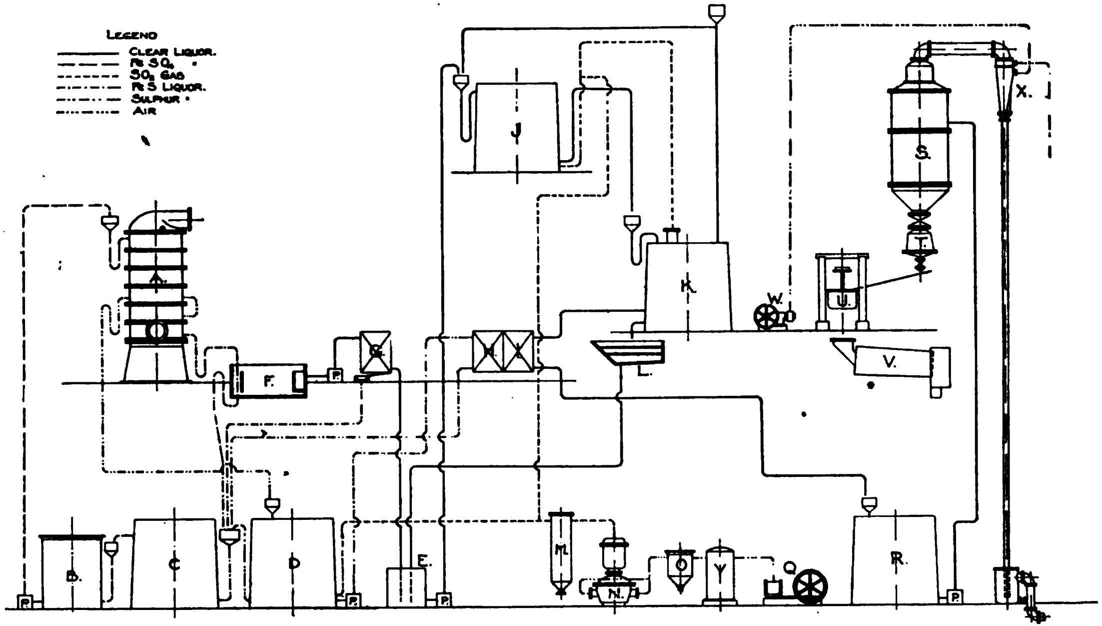
The tests of the salt in agriculture are stated to have been favorable, but further advice is awaited on this point.

The process has been placed in operation at several gas works in Germany.

The Feld Process.

Feld's process of sulphur and ammonia extraction from coal gas with the simultaneous manufacture of ammonium sulphate as practised at the works of the Central Union Gas Co., New York, is illustrated in Fig. 12.

Figure 12



Feld Process
of
Sulphur and Ammonia Extraction from Coal Gas
With the Simultaneous Manufacture of Ammonia Sulphate.

A solution of copperas is made in tanks D, C, and B. As soon as this solution is prepared it is pumped by pump P from tank B into the top of the washer A. The copperas solution ($FeSO_4.7H_2O$) reacts with the hydrogen sulphide (H_2S) and ammonia (NH_3) in the gas, washing out the entire ammonia contents and its equivalent in sulphur. This washing process takes place in the chambers of the washer A, the overflow from which being divided, a portion flowing over into tank D, and the other portion, passing through the three lower sections of the washer, flows into the settling tank F. The iron sulphide mud from F is siphoned off and passes into neutralizer tank C, while the clear liquor, separated by gravity in F, is pumped by P into filter press G, the clear liquor from the latter flowing into overflow tank E.

The liquor in tank D, having extracted the sulphur and ammonia, is now regenerated by the admission of sulphur dioxide coming from the sulphur stove N, the vessel M, interposed between the stove and the tank, being a sublimator for catching any free sulphur carried over in the gas.

This regenerated liquor passes through the same process as above described until it reaches a stage where it contains in solution from 30 to 40 per cent. of ammonium sulphate.

When the liquor has reached this degree of saturation the clear liquor containing the $(NH_4)_2SO_4$ passes from tank F through press G into overflow tank E as above described, while the iron sulphide mud from F is used to neutralize the acid qualities of the regenerated liquor coming from D.

While the wash liquor continually passes through the above process, the clear liquor containing ammonium salts is pumped from tank E into the acid mixer J, where it is again treated with sulphur dioxide in order to prepare the salts for oxidation; after this treatment the liquor overflows into oxidation tank K where it is treated with heat by means of a steam coil.

The heat in this tank decomposes the liquor into sulphate and sulphur, the sulphur being precipitated while the sulphate liquor is drawn off through filter-press I into the storage tank R; the precipitated sulphur is raked out of tank K into a

drain board L, the liquor from the latter passing back to tank E.

A certain amount of sulphur is precipitated out of the washing liquor in tank D, and this precipitation is daily pumped into filter-press H, the liquor from the latter flowing back into tank C, while the sulphur from presses H and I as well as from drain board L is burned into sulphur dioxide in sulphur stove N, the necessary air for combustion being supplied by the compressor Q, the air passing through the receiver Y and dryer O before entering the stove.

After tank R has been filled with a concentrated solution or from 30 to 40 per cent. strength of ammonium salts the liquor is pumped into the vacuum boiler S, where the liquor is evaporated and sulphate of ammonia produced, the latter salts passing through the salt catcher T into the centrifugal U, where the greater part of the moisture is thrown off, this latter liquor passing from the centrifugal into storage tank R. The salts from the centrifugal are passed into the rotary dryer V, and upon leaving the latter are ready for bagging.

The quantity of liquor boiled off daily in the vacuum boiler is replaced by water in the regeneration tank D.

The author wishes to acknowledge the assistance of Capt. W. E. Mc Kay, of the New England Gas & Coke Co., Boston, in the revision of the text and the preparation of the illustrations.

Thanks are also due to Messrs. F. E. Lucas, of Sydney, Nova Scotia, W. E. Hartman, Gas Engineer for H. Koppers, and W. H. Blauvelt, of the Semet-Solvay Co., and F. H. Wagner, of Bartlett Hayward Company, for assistance rendered in preparing this paper.

THE PRESIDENT: Next on our program is "Details of Manufacture of Sulphate" by Howell Fisher. I understand Mr. Fisher is not feeling well and that Captain McKay will read his paper.

Captain McKay: I might state that under the di·ret supervision of Mr. Fisher, the plant which he has described is at the present time producing thirty pounds of sulphate of ammonia per gross ton of coal, which, at the ruling market price, presents a gross return per ton of coal of ninety-five cents.

SULPHATE OF AMMONIA.
SOME DETAILS OF MANUFACTURE.

The manufacture of sulphate of ammonia in a plant of twenty-five to thirty tons capacity per day, while a comparatively simple process, has difficulties of operation that require experience and proper equipment to assure the economical and successful production of a commercial sulphate. Some of these difficulties are emphasized in the following description of the manufacturing operations:

As our plant has been in operation for over twelve years, our local and defined conditions may differ from those in plants of more recent construction; yet certain fundamental elements of the manufacture would be much the same, variations being chiefly a re-location of the different apparatus.

Sulphate plants of our type can be divided largely into two classes; first, using brimstone acid with the continuous saturator; and, second, using pyrites acid with intermittent saturator; our plant belongs to the second class. Brimstone acid enables the manufacturer to turn out a sulphate of good quality with little difficulty, whereas pyrites acid may cause a variety of trouble. With pyrites acid it is not advisable to use a continuous saturator; hence the reason for the two groupings.

To obtain a good grey white sulphate from pyrites acid, it is absolutely necessary to remove the sulphides of arsenic from the saturator. This can only be done soon after the saturator is put in operation, and before the acid reaches its highest temperature. The sulphides begin to form as soon as the

gas is admitted to the box, slowly rising to the surface. This scum increases in thickness sometimes to as much as an inch, and varies in color from light yellow and green to a dark brown, the higher the arsenic the greener the sulphides. A clapboard or thin board is used to collect this scum into one corner of the saturator where it is removed by a strainer made of sheet copper 1/16 in. thick, slightly bent, and perforated with 1/16 in. holes.

In the continuous saturator these sulphides cannot be collected and hence remain in the salt, and give the salt a yellowish brown color, which is very objectionable. The same thing holds true at times with the intermittent saturator, if the acid contains too much arsenic, as it cannot be wholly collected from the surface, and is then found in the sulphate.

For successful operation, acid of not under 52° Beaumé should be used; acid of a lower test results in an accumulation of mother liquor, and the disposal of mother liquor is quite troublesome. About the only way to dispose of the excess of mother liquor is by evaporation, using steam through a lead coil in a lead lined box, dipping out the salt as it is deposited. The salt, however, is not then satisfactory, as it is usually quite acid: moreover, the expense of the process is high because of the necessity of using live steam in the coil to obtain sufficient temperature for evaporation. Gas liquor can be used to neutralize the mother liquor before evaporation, to obtain a more neutral sulphate, but this procedure largely increases the amount of liquor to be evaporated, and it is dangerous to the operator, because of the liberation of large quantities of hydrogen sulphide.

Acid is received in tank cars of fifty tons capacity. They are unloaded by air pressure into an underground tank, a rubber hose with brass connections being used for the discharging connection. From this tank the acid flows by gravity to an air operated pump that elevates the acid to storage tanks under the roof of the building. The discharge from the pump is into a lead drum above the tanks, to provide for the

air discharge with the acid, thus preventing any splashing The outlets of these storage tanks are in the bottoms, and can be closed by a plug in case of emergency. Below these plugs in the pipe line is a valve for each tank to facilitate repairs to the line and tanks. The acid runs by gravity to each saturator with a valve for each outlet and further a valve on a low point on the pipe for draining in case of repairs. All of these valves are of cast lead of the globe valve type.

The operation of the saturator is as follows: The box is filled with acid and mother liquor, or not having sufficient mother liquor, with water to the proper height, making the strength 38° to 40° Beaumé. This strength should vary according to the salt capacity of the box and should be such that the box is not choked with salt before the acid is neutralized. After turning on the gas, as soon as the bath gets near the boiling point the operator collects the scum as previously described. For the next two or three hours no attention is necessary, other than to see that the proper temperature of the bath is maintained. This is best done by observing the temperatures of the inlet gases, if they rise above 95° C. there is danger of steam condensation in the box, which increases the volume and may cause an overflow. When the salt begins to deposit freely, it is necessary for the operator to push back the salt from the curtains to assure a circulation of the acid, otherwise the salt will be blackened or burnt, as it is called. When the strength of the bath drops to 32° Beaumé the gas is shut off, as that is almost the neutralization point. If the bath is allowed to become alkaline it will turn black from sulphides and spoil the color of the salt.

The salt and mother liquor is now dropped into the settling box through the outlet pipe, where it is allowed to remain for several hours to cool, in order that as much salt as possible will crystallize out of the mother liquor. It is then drained, shoveled into a cart taken to the centrifugal machine and dried, then wheeled to the storeroom.

The handling of the mother liquor is somewhat difficult, because as it cools, salt crystallizes out very freely and quick-

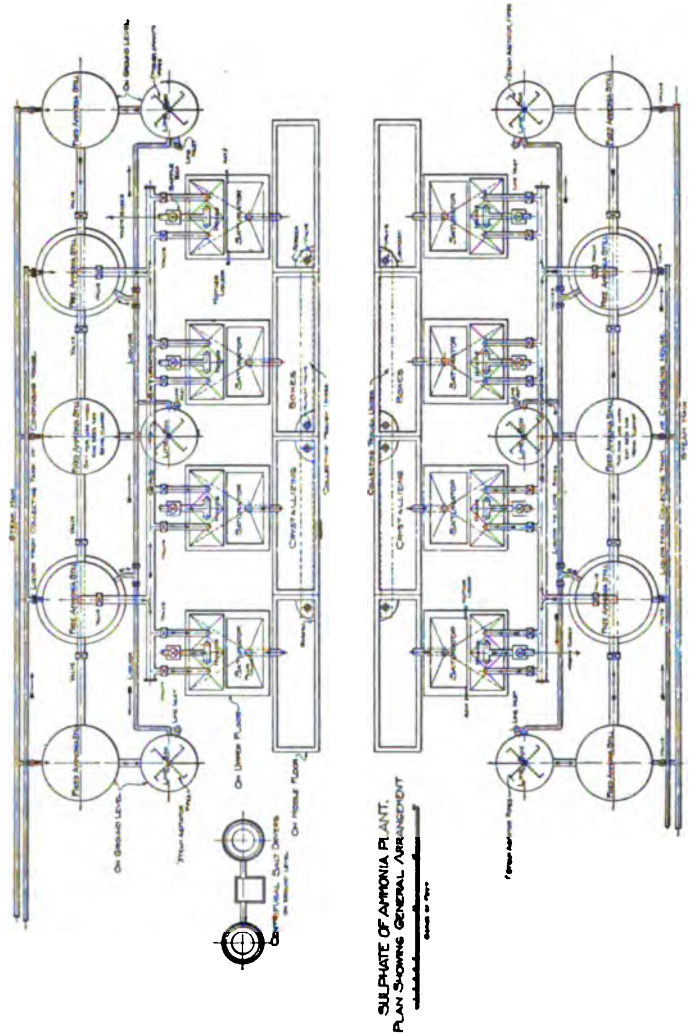


Plate 1.—Sulphate of ammonia plant. Plan showing general arrangement.

ly closes the pipes. All the mother liquor from settling boxes, centrifugal machines, etc., collects in lead lined cisterns under the main floor of the building, several catch boxes being in-

terposed on the way to remove the salt that is carried along

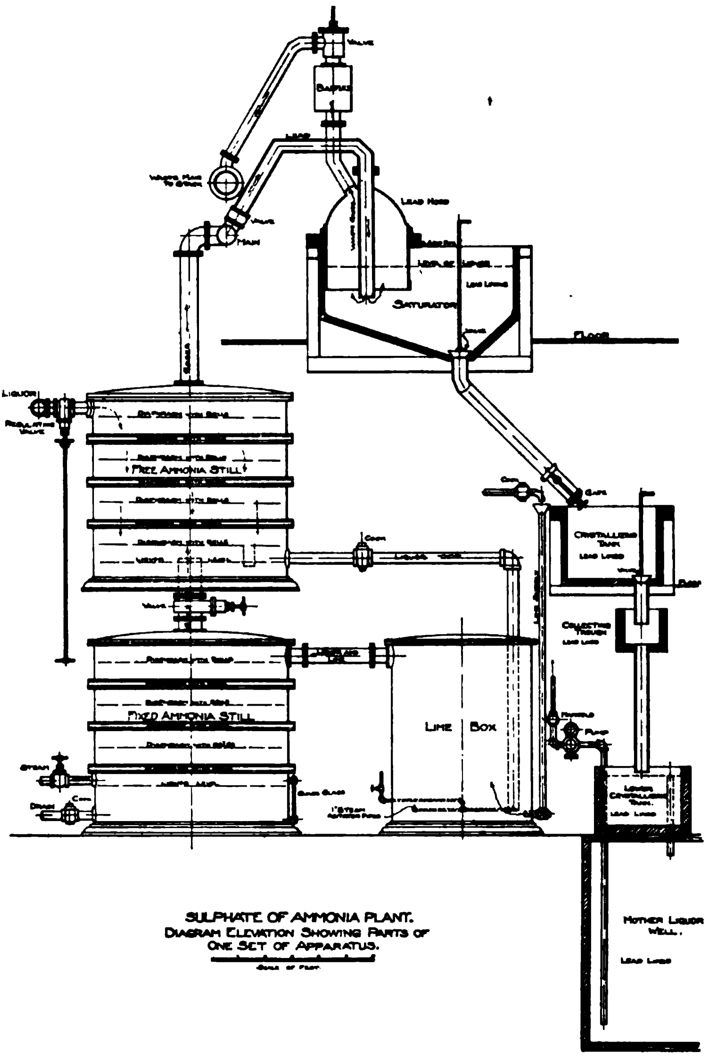


Plate 2.—Sulphate of ammonia plant. Diagram elevation showing parts of one set of apparatus.

mechanically, and thus keeping down the accumulation in the cisterns.

The Pump and pipe connections for mother liquor are shown in Plate 4. A brass pump is used for elevating the mother

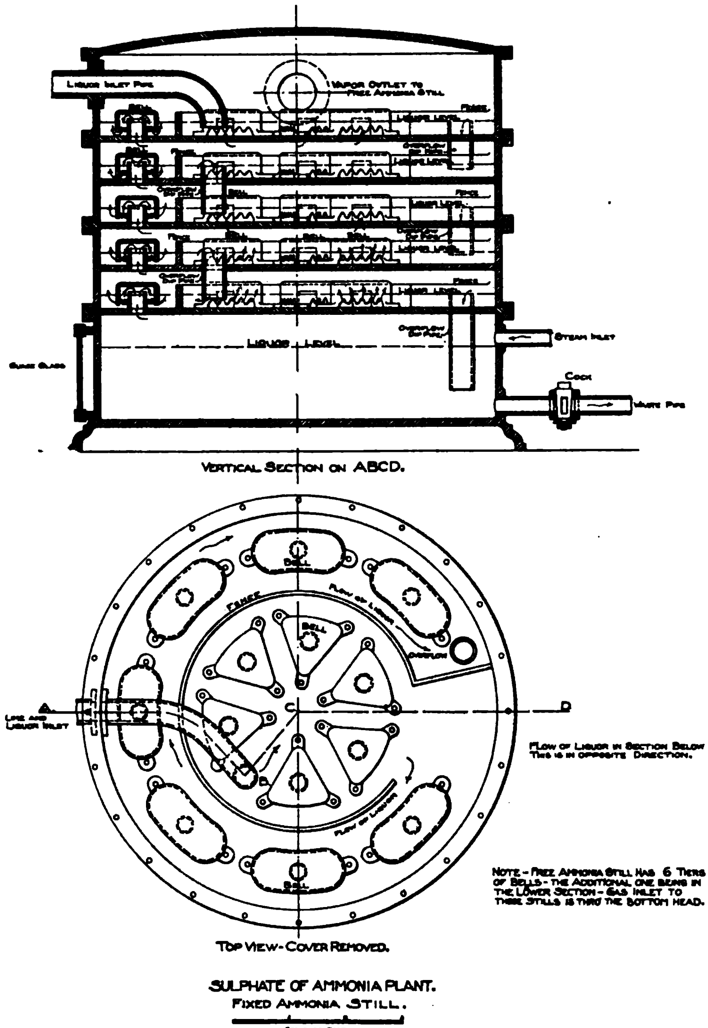


Plate 3.—Sulphate of ammonia plant. Fixed ammonia still.

liquor from the cisterns to the saturator, the piping arrangements being shown on the drawing. A gum rubber suction

hose is used in the cistern and connects above the floor to brass pipe. This makes a flexible arrangement for the varying amounts of salt and liquor in the cisterns.

The manifold drum on the discharge is to prevent the crystallization of the mother liquor in the pipes when not in use as each pipe is drained after being used. The pump and connections are frequently washed out with water to prevent accumulations of salt, the water being pumped from the sink through the pump and back into the sink.

The general arrangement of the plant is shown in Plate 1; and a diagram elevation of one set of apparatus is shown in Plate 2.

It will be noticed that the stills are set with three lime stills for each two free stills. The reason for this is largely because for several years the coal used in the plant gave a high percentage of fixed ammonia compounds, requiring the use of a large amount of lime. This, of course, necessitated frequent cleaning of these stills; and with this arrangement two stills could be out of commission all of the time. The fixed ammonia still is shown in plan and section in Plate 3.

The liquor is supplied to the free stills by gravity from an elevated tank, giving a practically constant head. Feed valves are of the all iron style with long extension stems to enable operator to reach them from the floor.

Steam for the stills is supplied principally at the bottom of the lime still, a little in the lime box for agitation, with a small auxiliary supply at the bottom of the free still. In both cases boiler pressure steam is used, being throttled as admitted. The amount is governed wholly by the operator's tests of the waste liquor, and the temperature of the distilled gases.

The saturators are placed on an upper floor: this has many advantages, principally that the handling of the salt is largely by gravity; it also prevents boiling over of the stills when being forced, and thus prevents iron salts from being deposited

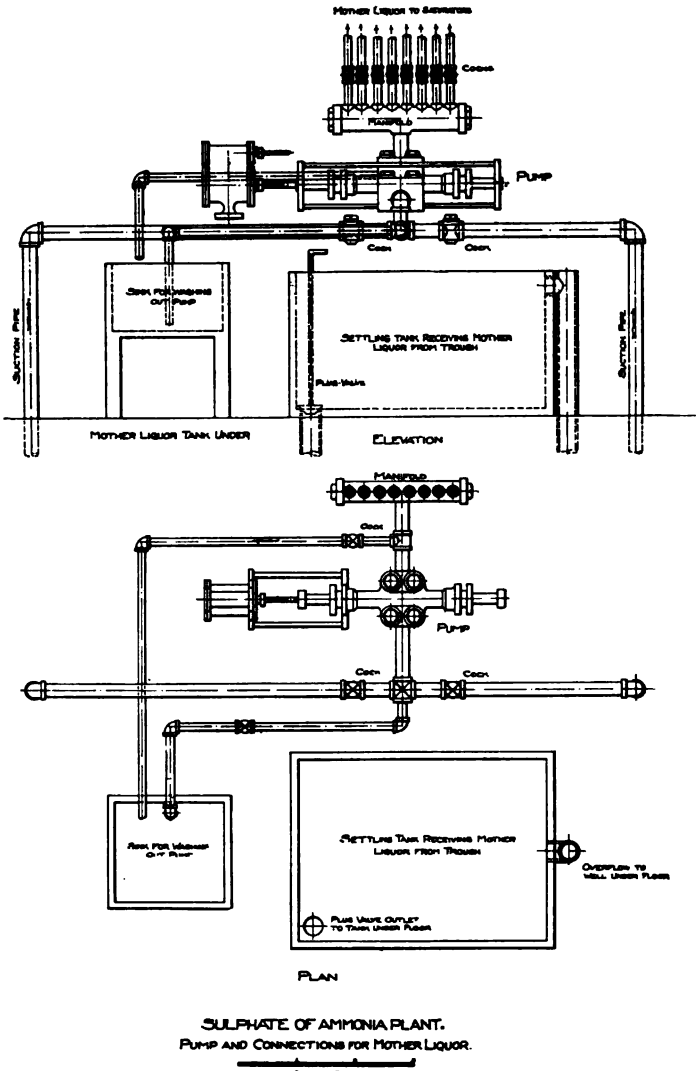


Plate 4.—Sulphate of ammonia plant. Pump and connections for mother liquor.

as ferrocyanides in the sulphate, with their well known blue color.

The saturators (shown in Plate 2) are of a wooden frame,

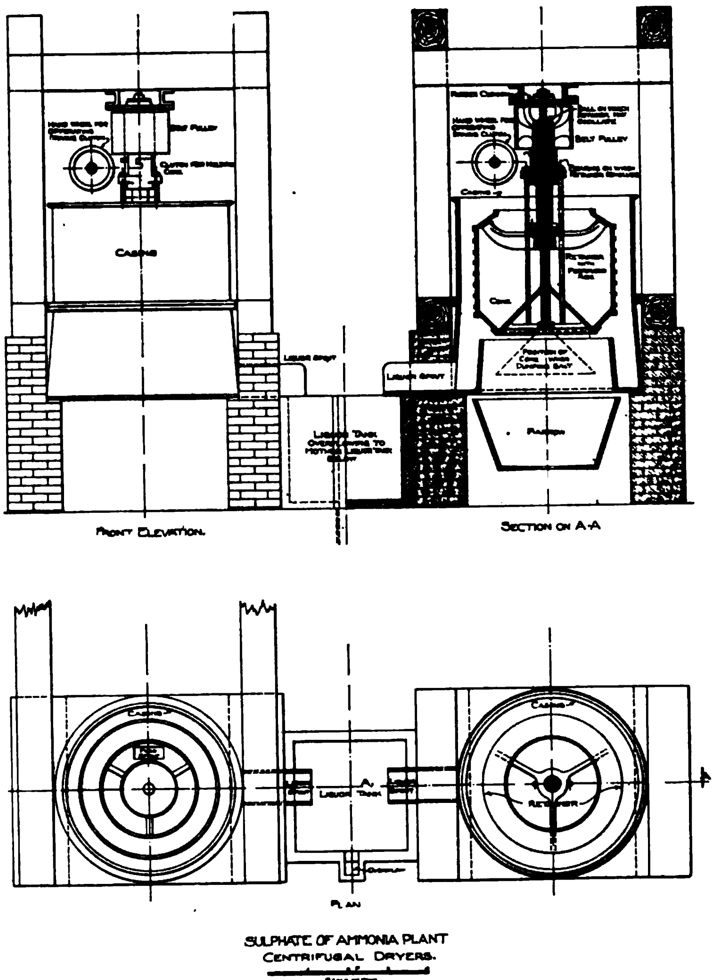


Plate 5.—Sulphate of ammonia plant. Centrifugal driers.

square type, with double square bells. Practically all of the

lead work is one-half inch thick and is serviceable without repairs for at least five years, while small repairs will add three

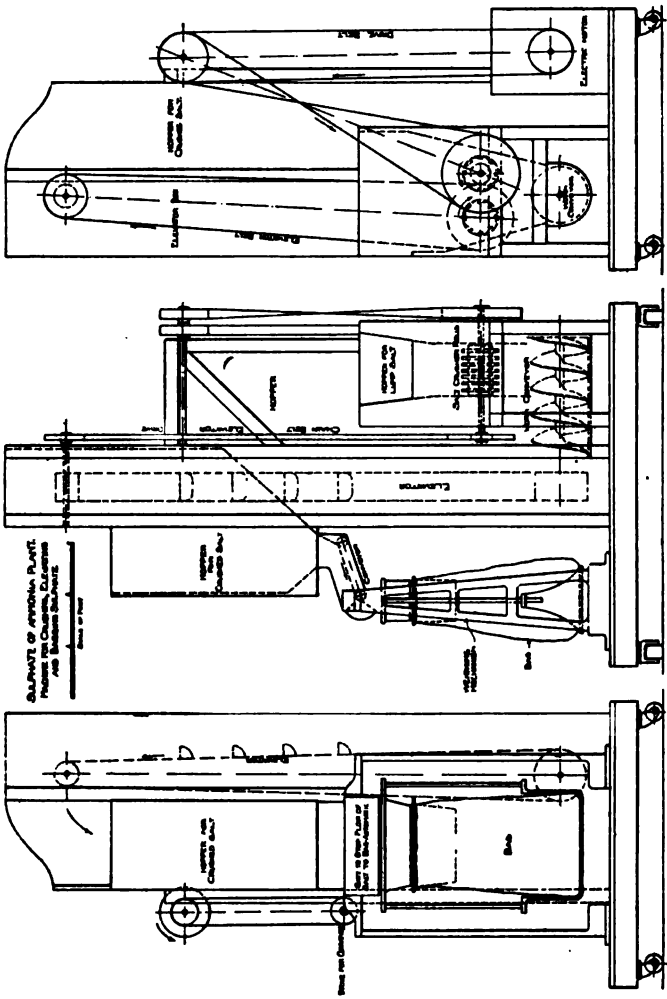


Plate 6.—Sulphate of ammonia plant. Machine for crushing, elevating and bagging sulphate.

more years to the box before relining. The capacity of the box is about 5,000 lbs. of dried salt.

The plug shown in the bottom of the box is merely for the

safety of the operator in removing the valve on the bottom of the outlet pipe. This valve is simply a flat plate with a gum rubber disc held by pressure against the end of the pipe.

The salt after draining is shoveled into a square, two-wheeled, wooden cart, which is wheeled to the centrifugal machine, being dumped through a brass chute into the basket. The basket is run at a slow speed until the charge (of about 800 lbs.) is all poured in. This is necessary because of the sticky nature of the sulphate, as fast running will cause uneven loading with possibly disastrous results.

A drawing of the centrifugal machine is shown in Plate 5. The basket has a drop bottom that is raised by a lever and secured by a clutch. The basket, bottom, shaft, etc., are all of brass, and have a life of from one and one-half to two years. The envelope and liquor collector around this basket is made of sheet lead, this forms a very satisfactory and safe casing.

It is essential that the sulphate should be allowed to remain in storage for four or more days before shipping to prevent shrinkage in transit, so accordingly it is piled on a wooden floor.

From storage the salt is loaded into bags with an automatic weighing machine, shown in Plate 6. The salt caking in storage is broken up by picks and shoveled into a crusher that disposes of all the lumps. It is elevated by a bucket conveyor into a hopper over the bagging machine into which it is fed by gravity. The capicity of the machine is from three and one-half to four tons per hour, which is the capacity of the crusher.

The drawing gives many details that have not been included in this description; the primary object of the paper is to point out some of the many troublesome points which are not usually mentioned in text books, yet which are of prime importance in the maintenance and operation of an ammonium sulphate plant.

The President: Gentlemen, the next paper is by Mr. A. D. Way—simply a bibliography of the subject. I will not ask Mr. Way to read the paper, but I want him to know that the Association realizes that it is a very laborious thing to get up and one of the most valuable things when you want to look into the subject.

Action of Calcium Cyanamide, Chili Saltpetre and Sulphate of Ammonia.
J. J. Vanha.
Zeitsch. landw. Vers. wesen., 1909, XII, 785-838.
Biedermanne Zentralbl., 1910, XXXIX, 526-532.

Ammonia and its Compounds.
Handbook by J. Grossmann.
D. Van Nostrand Co., New York City, 1907.

Ammonia and Ammonium Compounds.
Book by Dr. R. Arnold, 120 pages.
A. M. Callender & Co., New York City.

Ammonia, Coal Tar and
George Lunge.
A. M. Callender & Co., New York City.

Ammonia, Commercial Production of.
G. C. Tufts.
Jour. Ind. & Eng. Chem., May 11, 1911; Vol. III, 295.

Ammonia from Coke Oven Gas.
Sci. Am., S. LXIX, 172, March 12, 1910.

Ammonia Recovery, with Special Reference to the Apparatus Employed.
W. H. Johns.
Jour. Gas Ltg., Nov. 15, 1910, CXII, 489.

Ammoniacal Manure, Action of.
Jour. Gas. Ltg., July 13, 1909, CVII, 97.

Assimilability of Nitric and Ammoniacal Nitrogen by Plants.
Aime Pagnoul.
Ann. Agron., 1896, XXII, 485.

Available Nitrogen in Fertilizers, Bacteriological Methods of Determining the.
Jacob G. Lipman.
Jour. Ind. & Eng. Chem., March, 1910, 11-146.

Biggs, Wall & Co.'s Direct Fired Continuous Sulphate of Ammonia Plant.
Jour. Gas Ltg., Dec. 11, 1906, XCVI, 740.

Burkheiser Process, Sulphate of Ammonia Production by the.

Jour. Gas Ltg., Nov. 2, 1909, CVIII, 311.
Jour. Gas. Ltg., Nov. 2, 1909, CVIII, 326.
Jour. Gas Ltg., Nov. 16, 1909, CVIII, 477.
Jour. Gas Ltg., Oct. 4, 1910, CXII, 23.
Jour. Gas Ltg., Feb. 7, 1911, CXIII, 369.
Jour. Ind. & Eng. Chem., Dec., 1910, II, 556.

"Blue" Cause of, in Sulphate of Ammonia.

Jour. Gas Ltg., Aug. 29, 1905, XCI, 568.
Jour. Gas Ltg., Aug. 21, 1906, XCV, 500.
Jour. Gas Ltg., July 18, 1910, CIX, 177.

Centrifugal Separation for Sulphate of Ammonia.

Jour. Gas Ltg., Sept. 22, 1908, CIII, 780.

Continuous Treatment of Sulphate, Turbine for the.

Jour. Gas Ltg., July 12, 1910, CXI, 115.

Cost of Available Nitrogen.

Edward B. Voorhees.
Jour. Ind. & Eng. Chem., March, 1910, 11, 153.

Development of Ammonia Industry in Gas Works During the Last Fifty Years.

A. W. Hilgenstock.
Am. Gas Ltg. Jour., July 19, 1909, XCI, 248.

Difficulties in Sulphate Making.

Jour. Gas Ltg., Jan. 18, 1910, CIX, 176.

Direct Sulphate of Ammonia Manufacture.

Jour. Gas Ltg., Feb. 22, 1910, CIX, 496.

Equilibrium in the System: Sulphuric Acid, Sulphate of Ammonia, and Water at Thirty Degrees (30°).

G. C. A. Van Dorp.
Zeitsch Physikal Chem., 1910, LXXIII, 284.

Experiments on Ammonia and Nitrate Formation in Soils.

Jacob G. Lipman & Percy E. Brown.
Cents Bakt. Par., 1910, ii, XXVI, 590.

Experiments with Nitrogenous Fertilizers.

W. Schneidewind, D. Meyer & J. Graff.
Landw. Jahrbk., 1910, 39.
Erg. Bd., 111, 209.
Chem. Zentr., 1910, 11, 405.

Feld's Ammonia Plant.

Jour. Gas Ltg., Sept. 21, 1909, CVII, 761.
Jour. Gas Ltg., Sept. 28, 1909, CVII, 816.

Fertilizer, Sulphate of Ammonia as a.

Jour. Gas. Ltg., Dec. 11, 1906, XCVI, 736.

Interaction of Ammonia and Methane in the Presence of Carbon.
Jour. Gas Ltg., July 19, 1910, CXI, 171 and 191.
Glover, S., on Sulphate of Ammonia Plant.
Jour. Gas Ltg., Oct. 30, 1906, XCVI, 313.
Lawns, Sulphate of Ammonia for
Jour. Gas Ltg., Sept. 17, 1907, XCIX, 753.
Manure, Sulphate of Ammonia as a
Jour. Gas Ltg., July 23, 1907, XCIX, 236 and 266.
Manurial Value of Sulphate of Ammonia.
Jour. Gas Ltg., Jan. 14, 1908, CI, 81 and 89.
Modern Competitors of Sulphate of Ammonia.
Jour. Gas Ltg., Nov. 10, 1908, CIV, 414.
New Nitrogen Products, Sulphate of Ammonia and.
Jour. Gas Ltg., Sept. 25, 1906, XCV, 83.
Nitrifying and Ammonifying Powers of Soils, Method for Determination of.
F. L. Stevens and W. A. Withers.
U. S. Dept. of Agri. Bull., No. 132, 1910, 34-38.
Nitrogen, Effect of, on Root Formation.
Hermann Müller.
Jahresber., Versuchs-stat. Wädensweil, 1895, IV, 48.
Novelties in Sulphate of Ammonia Plant.
Jour. Gas Ltg., March 13, 1906, XCIII, 729.
Noxious Effluents from Sulphate of Ammonia Works.
Jour. Gas Ltg., May 22 and 29, 1906, XCIV, 514 and 588.
Noxious Effluents from Sulphate of Ammonia Works, Avoidance of.
Jour. Gas Ltg., March 27, 1906, XCIII, 863.
Organic Compounds in Sulphate of Ammonia.
Jour. Gas Ltg., Oct. 27, 1908, CIV, 281.
Plant for Small Gas Work, A Sulphate.
Jour. Gas Ltg., Aug. 22, 1905, XCI, 499.
Recovering Ammonia from Coal Gases and the Like as a Salt.
Jan. Adolf Roelofsen.
Jour. Ind. & Eng. Chem., Nov., 1910, II, 490.
Recovery of Ammonia in Gas Works.
Jour. Gas Ltg., Aug. 31, 1909, CVII, 580.
Recovery of Ammonia from Dry Distillation Gases.
Jour. Gas Ltg., July 13. 1909, CVII, 117.
Recovering Ammonia, Purifying Gas and,
F. J. Falding, Patentee.
Jour. Gas Ltg., Aug. 9, 1910, CXI, 392.
Small Sulphate of Ammonia Plant, Experiences with.
Jour. Gas Ltg., Aug. 17, 1909, CVII, 444.

Spent Liquor, Purification of.
Jour. Gas Ltg., Oct. 2, 1906, XCVI, 22.
Still, Operation of an Ammonia.
A. F. Blossey.
Amer. Gas Ltg. Jour., May 15, 1911, XCIV, 940.
Sulphate of Ammonia and Beet Cultivation.
Jour. Gas Ltg., April 5 and 19, 1910, CX, 16 and 162.
Sulphate of Ammonia from Cyanamide.
Jour. Gas Ltg., Jan. 18, 1910, CIX, 151.
Sulphate of Ammonia Plant, Itinerant.
Jour. Gas. Ltg., Aug. 16, 1910, CXI, 456.
Sulphate of Ammonia Production in Gas Works. Alkali Inspector's Report.
Jour. Gas Ltg., July, 1910, CXI, 21.
Sulphate of Ammonia Stills, Working of.
Jour. Gas Ltg., Jan. 23, 1906, XCIII, 227.
Sulphate of Ammonia and Power Gas from Peat.
Jour. Gas Ltg., Aug. 25, 1908, CIII, 520.
Sulphate of Lime, Treatment of Ammoniacal Liquors with.
Jour. Gas Ltg., April 16, 1907, XCVIII, 144.
Transport of Sulphate of Ammonia.
Jour. Gas Ltg., Jan. 29, 1907, XCVII, 290.
Treating Ammoniacal Liquor in Small Works.
Jour. Gas Ltg., July 12, 1910, CXI, 117.
Treating of Effluents of Sulphate of Ammonia Manufacturing.
Jour. Gas Ltg., Nov. 20, 1906, XCVI, 514 and 526.
Trial Plots of the Scottish National Exhibition.
Jour. Gas Ltg., Sept. 22, 1908, CIII, 786.
The Manufacture of Sulphate of Ammonia.
Gascoigne T. Calvert.
Book published by John Allen & Co., London, 1911.

THE PRESIDENT: The matter is now open for discussion. I shall be very glad to hear from any one who wishes to discuss any one of the four papers at the present time.

MR. R. M. SEARLE: I want personally to give my thanks to the American Coal Products Company for their propaganda. I know the work they did before Congress, having been asked by them to assist as many other gas men were, and having made many trips to interview repre-

sentatives in Congress, in order to get them to sustain the tariff on sulphate, without however any success. The work that Mr. McIlravy has done abroad no one can appreciate. Captain McKay has just said Mr. Fisher's plant realizes ninety-five cents per ton of coal; without the good work done in Germany and in England by Mr. McIlravy it would have been sixty cents per ton of coal. So that the development under the eyes of the men in this country is bound to come, if gas men will boost as Germany is boosting. I am not proselyting for the American Coal Products Company but for the gas business, if we will boost in this country, the total amount of sulphate of ammonia will not be only three per cent. of the total consumption. The palpable ignorance of the gas industry in this connection is something appalling. We see the possibilities in this respect as we come into agricultural work as we have been doing in our electrical department, in the study of the recovery of nitrogen from the atmosphere and utilizing it for fertilizing work; we realize from the electric side the loss to the gas men. It is our duty to get the best price we can for sulphate of ammonia and this is one of the most useful and philanthropic uses we can put it to. It seems strange that it should be necessary—although necessity is the mother of invention—for a concern almost foreign to our business to come and tell us what we ought to do for our own benefit. That applies just now in two lines. In one case a gas man tells an automobile man how to run his business and tells him successfully, and an outside commercial man tells us how to run another branch of our business successfully.

Mr. Gartley: I understand he refers to Mr. Fisher's plant as producing thirty pounds of sulphate of ammonia, which is about 7½ pounds of ammonia per ton of coal. I suppose we will all agree that the amount of ammonia that is produced from a ton of coal is not the function of the apparatus that makes it into sulphate, but of the methods used for carbonizing the coal. I understand that the Mond

process will give us very much more ammonia than that. Mr. McIlravy has suggested the advisability of our taking up propaganda for the use of sulphate of ammonia. Has he any way that he would suggest to the gas companies as particularly advantageous for them to handle their ammonia product?

I should also like to ask in connection with Mr. Atwater's paper if there is anybody in the room who has seen the Burkheiser process in actual successful operation in Germany—whether it is true that the Burkheiser salt will require another propaganda to get the fertilizer used, because it is two-thirds sulphate and one-third sulphite and that therefore its value as a fertilizer will have to be demonstrated fully to the users in this country?

THE PRESIDENT: I am going to ask the authors of these four papers to discuss them just as the other members do, because no one of them is the author of all four, and certainly they are all interested in them. Gentlemen, I shall be very glad to hear from any other member, especially from some one who can answer Mr. Gartley's question. Undoubtedly of all the Americans who have been in Europe this summer some one must have seen this process. Gentlemen, unless the other members want to discuss the papers further I shall be glad to hear a motion of thanks to the gentlemen and espeially to Mr. A. B. Way for the papers that they have presented. They contain a great deal of information which the gas men want.

CAPTAIN McKAY: I move a vote of thanks on the papers presented by the American Coal Products Company. I think we very fully appreciate the work they have done and the information they have given us.

THE PRESIDENT: Gentlemen, it has been moved and seconded that the thanks of this Association be presented to Mr. Atwater, Mr. McIlravy, Mr. Fisher and Mr. Way for the papers they have presented to us on the subject of

sulphate of ammonia. Those in favor of that motion will signify the same by saying aye.

The motion was carried unanimously.

THE PRESIDENT: The next subject before us is the report of the Editor of the Wrinkle Department. From page 36 to page 141, Part II, is before this meeting. The rest of it consists of distribution topics and is before the meeting downstairs. (No response.) Gentlemen, if the members do not wish to discuss the report of the Wrinkle Department, I am going to call for the reading of the Report of the Bureau of Information.

Mr. Klump then read in an abstract the report of this Committee, and stated impromptu:

"The Bureau of Information this year had only some ten (10) questions submitted, and the answers to these are included in this report. Where two (2) replies to one question were received, and did not conflict, both were given.

"The members have not availed themselves of the advantages that such a bureau represents, due probably to the fact that the reports are too infrequent, and the subject is not brought to their attention forcibly enough.

"The issuance of a periodic bulletin by the Institute would be a means of overcoming this objection, and if the questions and answers were printed and issued often to members it might create more interest and be of more value.

"I herewith present the report, as compiled, by Mr. M. Webb Offutt, Chairman."

MR. R. M. SEARLE: There are two items I should like to call attention to, one in the Bureau of Information in the Question Box, and the other in the Wrinkle Department. On page 66, Part II, there is a wrinkle put in by Mr. McDonald for the recovery of iron monoxide. This system has been worked out so successfully and perfectly at Louisville that it has resolved itself into a matter of purification, not a determination of the amount of sulphur in the iron oxide

but what the cost of handling a bushel may be. It doesn't make any difference how much sulphur there is in the oxide when the box fouls we have to take it out. By this device or wrinkle it is much cheaper. The feature under this wrinkle would be the saving of the labor involved. I want to point out those two features.

MR. FULWEILER: I should like to ask whether he finds the efficiency for purification diminished on successive recoveries, whether the iron is equally efficient for purification after recovery?

(The President asked Mr. Eustace to take the chair temporarily. Mr. Eustace took the chair.)

MR. McDONALD: I did not make that analysis, but I do not want to cast any doubt on the analysis. I can, however, answer Mr. Fulweiler, in a perfectly matter of fact way. We took this recovered oxide and passed a measured quantity of H_2S through it, and then took the same weight of the original natural oxide which we purchased and passed H_2S through that. The recovered oxide absorbed more cubic centimeters of sulphuretted hydrogen than the original freshly purchased oxide did, but I want to say here that until we sprinkled the batch with ammonia liquor, it would not absorb any sulphuretted hydrogen at all, and I rather think that some people may have attempted this matter and failed to get any absorption of sulphuretted hydrogen because they neglected to neutralize the acid in the recovered iron.

MR. WHITTAKER: The Bureau of Information complains of lack of patronage. It appears to me not enough publicity is given to this department. This morning there were introduced 70 new members and I have been wondering what steps will be taken to exploit our different departments for the benefit of our new members and for other members not acquainted with these departments.

A suggestion has been made that a book or some publication be made once or twice during the year to set forth

the advantages of the Institute. I think this would be a very good thing and it should be kept separate from the regular formal Proceedings. Take for instance the Committee on Calorimetry. These gentlemen have done a large amount of work and yet it would be a hard matter for a new member to trace the origin and the work of this committee.

(At this point the President resumed the chair.)

THE PRESIDENT: I presume the bulletin which the secretary has been instructed to issue will cover such information as you have suggested.

Gentlemen, that completes our program for this afternoon. I want to say now before you go that the program for to-morrow is a very long one and in order to get through we must start on time, so I am going to ask you to be here early. I want to remind you also that the parallel meeting in the lower hall will begin at the same time that we begin up here, that is at 10.00 A. M. I declare the meeting adjourned.

Adjourned at 4:40 P. M.

Wednesday, Oct. 18, 1911.
2:00 o'clock P. M.

The members of the convention designated as Section B under this date, were called to order in the lower hall of the Art Museum Building at two o'clock P. M., Mr. W. Cullen Morris, of New York, in the Chair, and Mr. Walton Forstall, acting as Secretary.

The Chairman opened the meeting by inviting discussion of the Wrinkle Reports, commencing with No. 35. Mr. von Maur opened the discussion by inquiring in regard to Wrinkle No. 66, Anti-Freezing Attachment for Outside Arc Lamps.

The next wrinkle is a sand feeder, used for feeding dry sand at a fixed rate onto a governor. Any discussion on this or similar devices.

The next is a photometric screen, a double diaphragm revolving screen, which takes the form of a drum.

The next is a gas stand for an illuminometer.

The next shows a convenient arrangement of a fitting shop. Some of you ought to have something to say on that, as it is a matter a little nearer home. These wrinkles are Nos. 41, 42, 43, and we are discussing these wrinkles to give the gentlemen a chance to come in in the meantime. I judge you are all familiar with such an arrangement, and I would like to have such a discussion.

MR. VON MAUR: I will simply ask the question, has anybody ever used any other oil than neutral oil for oiling the diaphragm meter?

THE CHAIRMAN: Gentlemen, you have heard Mr. von Maur's question. Has anybody found any better oil than neutral oil for oiling the diaphragms of meters?

MR. WALTON FORSTALL: In Philadelphia we have never seen any reason to change from the neutral oil that we first started to use on our diaphragm meters. At present we have 300,000 of these meters in use.

THE CHAIRMAN: Has anyone else had any experience?

MR. J. W. BATTEN: There are shops in different parts of the country that have been using neutral oil for four years, and they use neutral oil entirely. They have not found any occasion to make any change. It has been doing the work satisfactorily.

THE CHAIRMAN: The next wrinkle is No. 68, barricades for ditches.

MR. VON MAUR: Of course, the wrinkle is not for this purpose, but I want to ask if there is any use for the dial lid on the meter.

MR. F. HELLEN, of Rochester, New York: I believe that it is an improvement in protecting the glass face of meters, if for nothing more than transportation from one job to another. We used to have a great deal of trouble with the broken glass, and in the last three years we have insisted on

the inspector closing the covers by putting glasses on the meters. When we looked up and made a note of the particular district, we had no trouble from that condition. We very seldom at the present time find a meter with a broken glass. All our meters have been changed in the last five years. I think it is very important.

A MEMBER: Mr. Hellen, could you accomplish the same result by having a thicker glass?

MR. HELLEN: I don't know about that, but going back to the time that I inspected meters personally, I know we are more careful in those matters to-day than we were fifteen years ago, we were very crude at that time, particularly, in handling meters, and a thick glass would be no protection whatever. I think the cover is a protection, and I think experience goes to show today that the cover on the meter is far ahead of a thick glass cover.

THE CHAIRMAN: Mr. Hall, we are just discussing the covering over the index of meters, and it has been suggested that we could do away with the cover by thickening the glass over the index. Have you any experience with that at all.

MR. A. H. HALL, of New York: We gave up the use of covers for a while, and then we returned to them, as we found they were a better protection. I have had no experience with thicker glass.

MR. H. W. TERRY, JR., of Ossining, New York: With regard to the question of using glass on meters for a dial cover, I would suggest the use of something such as is used for automobile screens, which would be tough and would not break. The only difficulty with that would be that it is celluloid, which is a substance that might take fire.

THE CHAIRMAN: We will discontinue the discussion on Wrinkles now, and pass to the first paper, "Insulation as a Means of Minimizing Electrolysis in Underground Pipes," presented by E. B. Rosa and Burton McCollum, representing the Bureau of Standards.

INSULATION AS A MEANS OF MINIMIZING ELECTROLYSIS IN UNDERGROUND PIPES.

The protection of gas and water pipes and other buried structures from damage by electric currents has long been one of the most important, and at the same time one of the most difficult problems with which the engineer has to contend. There are few problems that affect a greater diversity of interests or which involve the welfare of greater amounts of property than those arising from the presence of stray currents in the earth. The phenomena of electrolysis of gas and water pipes by stray currents from electric railways have been the subject of a vast amount of study and experiment, and much information has been brought to light and a great deal of progress made in methods of minimizing trouble from this source. There remain, however, many problems on which further light must be thrown before remedial measures can be applied with that degree of certainty which modern engineering practice demands. Closely related to electrolysis from stray currents, and inseparable from it in any comprehensive investigation of the subject, is the phenomena of self corrosion or auto-electrolysis, due to the presence of cinders, particles of coke, and other substances which give a difference of potential against iron, or due to the physical condition of the pipe itself. The corrosion due to this cause is fundamentally a phenomenon of electrolysis, and the resulting damage is often difficult, if not impossible, to distinguish from that due to stray currents from electric railways. During recent years, also, much attention has been drawn to the possibility of the destruction of reinforced concrete structures by stray currents, and considerable apprehension has been aroused lest reinforced concrete buildings, bridges, etc. might be damaged or destroyed by electrolysis. Whether or not such grave danger actually exists in practice, the possibility of such danger having been established, the problem becomes one of extreme importance, since not only are vast property interests concerned, but there exists also the possibility of serious hazard

to human life. Further, any measures that may be taken to protect gas or water pipes from electrolysis will at the same time affect in greater or less degree the possibility of danger to reinforced concrete structures, since the pipes usually enter such buildings and afford one of the principal means of entrance of stray currents into the reinforcement of the concrete. It is evident, therefore, that any comprehensive investigation into the subject of electrolysis must be considerably broader in its scope than those investigations usually undertaken with a view to protecting pipes alone. Recognizing the importance of the subject and acting in response to requests from important engineering interests, the Bureau of Standards has undertaken an investigation with a view to throwing as much light as possible on the different phases of the problem and their relation to each other.

The work was begun on July, 1910, and has since been carried on by laboratory investigations, by correspondence with engineers and corporations, and by investigations in the field under practical conditions. During the fall and winter of 1910, the work was confined largely to a study of the effects of electric currents on concrete, and of auto-electrolysis, but in the early part of 1911, the work was extended to include laboratory and field work covering the general subject of electrolysis, special attention being given to methods of minimizing electrolysis. It is not to be expected that an investigation of this character and magnitude can be brought to a conclusion in a single season, and up to the present time only certain phases of the problem have been investigated fully enough to justify even a progress report being made on them at this time. Much important work in connection with various methods of minimizing electrolysis remains yet to be done, and it is planned that this work shall continue as long as circumstances may require.

In taking up this problem it is not the intention of the Bureau to make investigations under local or exceptional conditions with the view merely of remedying the evil in particular

cases, nor to invade the field now occupied by the consulting engineer, but rather to confine ourselves to the broader and more general aspects of the problem, and to render as much aid as possible in bringing to light information, and in establishing general principles which may be of service to the engineer in dealing with the infinite variety of situations that present themselves in practice. Of the dozen or more methods that have been proposed or tried for minimizing electrolysis, there is none which will not, when properly carried out, result in greater or less reduction in the damage due to stray currents. On the other hand, there are few, if any, of these methods which will not, when wrongly applied, yield unsatisfactory results, either through failure to accomplish the results desired or by imposing unnecessary hardship on the parties interested. Vast sums have been spent in unsuccessful and ill-advised attempts to remedy the evil, and these errors could have been avoided if the persons in charge of the work had had a thorough knowledge of the difficulties confronting them. It is of first importance, therefore, in dealing with any situation where serious damage may occur, to place the work of mitigation in charge of a competent engineer. The farther our knowledge of the subject advances, the more important this becomes, since only the specialist can be expected to acquire that broad knowledge of the subject and the maturity of judgment that is essential in securing the maximum of protection at a minimum cost.

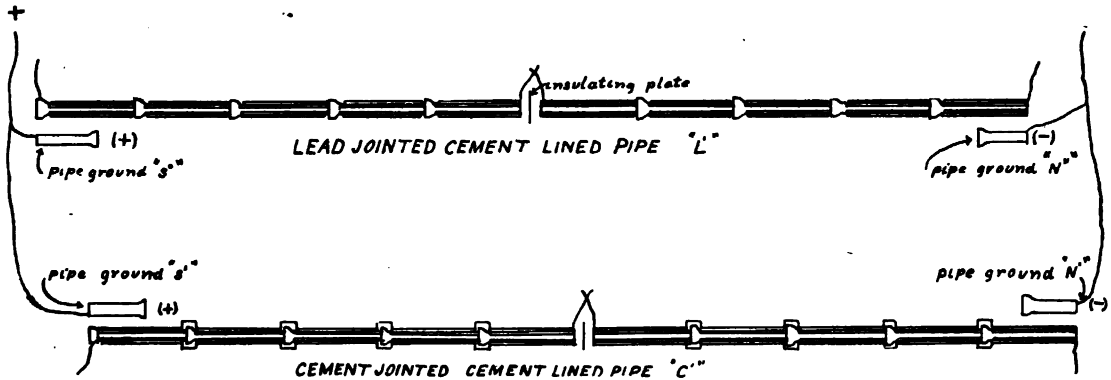
In discussing the various remedies that have been proposed for reducing the damage to pipes, due to stray currents, the methods may be broadly grouped under four heads, viz., (1) those which have for their object the keeping of the currents off the pipes altogether, or reducing them to a negligible quantity, (2) those, which while they do not tend to reduce the currents in the pipes, but rather to increase them, are designed to permit the currents to flow off in such a way that they can do little or no injury, (3) those which contemplate the use of alternating currents or periodically re-

versed currents in connection with railway systems, and (4) the use of chemicals such as lime around the pipes to prevent electrolytic action.

The first of these methods may again be sub-divided into four groups, viz., (1) those methods which aim to eliminate earth currents entirely, as the double trolley system, and its equivalents; (2) those which aim to reduce the differences of potential between different portions of the system, to so low a value that they will do no appreciable harm, as by the use of negative return feeders to rails, careful bonding, boosters, etc.; (3) those methods while they make no attempt to reduce potential differences in the earth, due to the railway currents, aim to locate the pipes where the potential gradients are too low to cause appreciable currents to flow in them; and (4) those which aim to protect the pipes by some method of insulation or partial insulation whereby the currents on the pipes are reduced to a negligible minimum. While investigations have been in progress for some time, tending to throw light on all of these various methods, and they will be treated in later reports, only the last one, viz., the method of insulation, will be dealt with in the present paper. In thus confining ourselves to the discussion of one general method of minimizing electrolysis it is not to be understood that we regard this as necessarily the best method of preventing the trouble but rather because our investigations relating to other methods have not yet been carried far enough to justify us in attempting to summarize the results. Further, our investigations relating to the method of insulation will be pushed further, and other and more complete papers will be published as the work proceeds.

When troubles from electrolysis first began to assume serious proportions following the general introduction of trolley systems in cities, one of the first remedies to suggest itself was that of insulating the pipes. Numerous attempts were made at different places to protect pipes in this way but in most cases the results were uncertain or unsatisfactory. At-

tempts were made to protect pipes by laying them in conduit and in other cases by imbedding them in cement but neither of these methods proved of material value. The reason for their failure is simply that such materials absorb moisture and when wet have considerable electrical conductivity so that current can enter and leave a conduit enclosed or cement coated pipe almost as freely as one laid in earth. One company is now manufacturing a cement coated, cement lined pipe which it claims has in a number of cases been subjected to quite severe conditions for years without any trouble from electrolysis, and this freedom from trouble has been attributed to the cement coating. In these cases however the pipes were laid with cement joints also and there is every reason for believing that these have been responsible for the protection afforded the pipes. The company which manufactures these pipes has, however, had considerable trouble with the cement joints due to mechanical imperfections and has recently adopted the use of lead joints in connection with the cement coated pipes, and is installing them on the assumption that these will be as free from electrolysis as the older line with cement joints. In order to test the relative value of the two kinds of pipe lines and to determine if possible whether the cement coated pipes with lead joints would be more affected by electrolysis than the same pipes laid with cement joints, the Bureau of Standards has laid in Washington, two parallel lines of such pipe one hundred feet long and twenty feet apart, one using cement joints throughout and the other using lead joints throughout, and has kept them subjected for some months past to identical conditions as regards danger from electrolysis. The arrangement of the pipes is shown in Fig. 1. Near each line at either end and about two feet from the pipes was buried a single length of ordinary cast iron soil pipe and these were connected together in pairs as shown and used as terminals on which a difference of potential of about 15 volts was constantly maintained. At the middle of each line an insulating plate was inserted to separate the two halves electrically and two



Showing arrangement of pipes for comparing effect of lead joints and cement joints in cement covered pipes

Fig. 1.

insulated leads were brought up from the ends adjacent to the place in which an ammeter could be inserted for the purpose of measuring the current flow in the pipes. The readings obtained from time to time are shown in Table I. It will be noted that the current in the line having lead joints is several hundred times greater than in the cement jointed line. On October 13, 1911 a portion of the pipes were uncovered near the positive end and examined and it was found that while the pipes provided with cement joints were still in practically as good a state of preservation as when first laid, the line having lead joints showed marked evidence of corrosion, the outer metal sheath protecting the cement coating of the pipe proper having been eaten entirely through in several places.

TABLE I.—SHOWING CURRENTS FLOWING IN PARALLEL LINES OF CEMENT COVERED PIPE, WITH BOTH LEAD AND CEMENT JOINTS.

	June 19	June 23	June 30	July 7	July 14	July 21	July 28	August 11
Current in lead jointed line I_L	0.275	0.278	0.265	0.290	0.245	0.265	0.268	0.275
Current in cement jointed line I_C	0.0012	0.0011	0.0009	0.001	0.0008	0.0014	0.0009	0.0007
Ratio $\frac{I_L}{I_C}$	229	252	294	290	306	186	297	393

These results indicate very clearly that the immunity from electrolysis which these pipes have possessed in the past is due mainly to the fact that they were laid with cement joints, and that the same pipes laid with lead joints is now being done are by no means free from trouble, the cement coating in itself not being effective in keeping the current off the pipe. This is further substantiated by experiments recently carried out at the Bureau of Standards on the subject of the electrolysis of iron imbedded in cement and concrete. Table II gives specific resistance measurements on a number of samples of earth taken from around pipes in different cities, and also specific resistance measurements on specimens of wet Portland cement. The figures show that

while there is considerable variation in the specific resistance in both the earth and concrete, the average resistance of the cement and concrete is lower than that of the earths tested.

TABLE II.—SHOWING THE RELATIVE SPECIFIC RESISTANCE OF REPRESENTATIVE SPECIMENS OF EARTH AND WET CONCRETE.

Per cent. moisture in soil	Specific resistance of soil	Character of soil	Character of concrete	Specific resistance of concrete after soaking in water 24 hours
10.23	8,709	sandy	—	—
12.28	2,914	sandy	—	—
13.23	1,335	sandy	—	—
20.48	2,300	clay and vegetable matter	—	—
21.84	1,074	earth and cinders	neat cement	6,100
26.53	14,025	blue clay	1:2 mortar	3,200
5.97	44,440	yellow clay and gravel	1:2½:4 concrete	4,900
16.72	1,797	clay and gravel	1:3:5	4,700
19.29	3,783	blue clay	—	—
Average for soil	8,930	—	—	4,725

Further, it has been shown by several investigators that iron imbedded in cement or concrete not only corrodes quite readily when an electric current flows from the iron to the cement, but the cement itself is soon destroyed by the mechanical pressure developed around the iron.

Painting of pipes or otherwise insulating the surface by the use of treated papers and textiles was early resorted to as a possible method of protecting pipes from electrolysis, and this method is still resorted to in some instances. It is doubtful, however, whether there exists any instance in which it has been definitely proven that insulating paints have effectually protected pipes from electrolysis, while there are many instances where they have failed utterly and where their presence has probably done actual harm. This statement may seem somewhat surprising to some who are familiar with instances where paints have withstood the action of soils for a long period of years and when uncovered both paint and

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pipes appeared to be in practically as good condition as when they were laid years before. Practically all such paints are commonly classed as insulators and it is quite natural therefore that the impression should be gained by many that these paints ought to prove equally as effective as a protection against corrosion in the soil. In practice, however, such paints behave in a very uncertain manner at best. A given paint may endure for long periods in some places while in other sections of the same city this same paint may deteriorate rapidly and become worthless in a comparatively short time. This is due partly, no doubt, to differences in soil conditions but the general failure of these paints under conditions where electrolysis was to be expected indicates that stray currents themselves may have something to do with the destruction of the coatings. With a view to throwing light on this point and also to determine if possible something of the relative value of different paints and coatings as a possible protection against electrolysis, the Bureau of Standards has undertaken a series of experiments which although still not completed, have yielded considerable definite information.

In testing a paint under conditions approximating those met in the prevention of electrolysis by stray currents it is very desirable to obtain for the test as perfect a coating as possible. This insures a test of the paint and not a test of a method of application of the paint itself. The object of this of course is absolute fairness to the manufacturer. To obtain a coating which comes up to the requirements of the test, a sufficient number of coats must be applied to completely eliminate all pinholes and flaws. The application should preferably be made to a flat, or nearly flat, smooth surface of iron having no projections or rough spots. Each coat must be thoroughly dried before the next is applied. Care must be taken to see that the surface on which the paint is to be spread is free from grease, scale or rust, especially grease, and that the paint is thinned sufficiently to spread well. In brushing on quick drying paints the brush should not be passed over the surface again after the paint has gained its

initial set which usually takes but two or three minutes. The paint must be spead thin enough so that it will not run in ridges and dry or leave blisters. If these precautions are observed four coats of any paint are generally sufficient to give a coating free from flaws.

To obtain a smooth, nearly flat, surface, and at the same time a great many other distinct advantages, sheet iron cones like those shown in Fig. 2, having 8 inch diameter of base and 1 ¾ inch altitude were made. The interior of the apex was filled with solder to a depth of ½ inch and the inner seam where the iron lapped over was soldered to a smooth joint thus making the cones water tight and doing away with the sharp corner at the apex which would be difficult to paint. The interior surface of the cone, after being thoroughly cleaned, was then painted according to the procedure set forth above. When the coat of paint was completed a portion of the surface a little more than covering the solder at the apex of the cone was strongly reinforced against electrical stress with a layer of felt saturated with asphaltum. This did away with the effect of any chance projection of the solder and made it certain that any possible failure of the paint would occur where the paint had been applied to a smooth surface.

The advantages of the cone over a rod or pipe are these:

1. The surface being more nearly flat is easier to paint uniformly. There are no ends or sharp corners where defects may appear. 2. After painting it can be laid down anywhere to dry and there is very little chance of its being bruised in handling. 3. To measure the electrical resistance and dielectric strength of the coating the cone can be filled with electrolyte and the voltage applied. The results' will be free from inaccuracies due to sharp corners. The same applies to long time tests on low voltages and also does away with the necessity of any containing vessel for the specimen.

The tests applied were as follows:

1. Preliminary test for pinholes and flaws. This test consisted in filling the cone to about ¾ inch from the rim with a

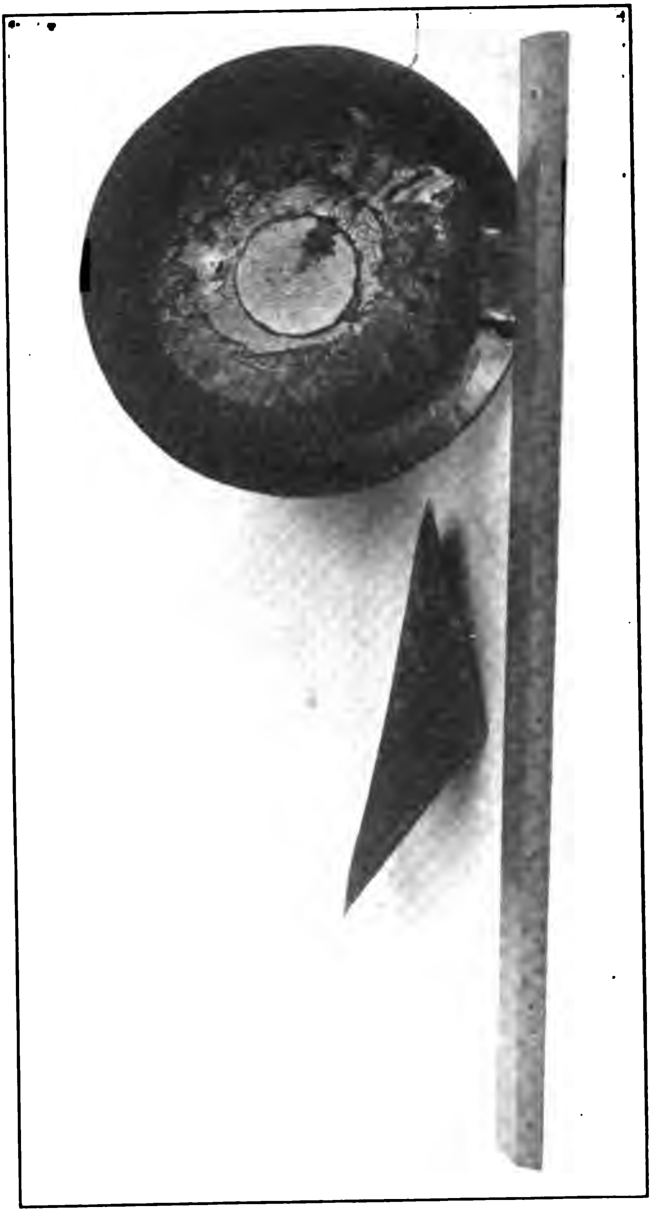


Fig. 2.

weak solution and applying 80 volts alternating current for 30 seconds immediately after filling; the difference of potential being applied between the sheet iron of the cone and the electrolyte. An alternating current mil-ammeter placed in the circuit gave a kick of the needle if the coating was defective. Only those specimens which showed no defects under 80 volts pressure were used in succeeding tests.

2. Resistance measurement of the paint coating. This test (and those following) was applied to specimens which survived test No. 1. The measurement was accomplished by filling the cone with mercury and measuring the resistance between the sheet iron of the cone and the mercury by means of a Wheatstone bridge.

3. To test for the effect of dampness alone, or the effect of various chemicals on the paint coating, the cone was filled with the desired solution and allowed to stand. Electrical resistance measurements from time to time showed the decrease of protective value of the paint by absorption of moisture or chemical action by a decrease of resistance.

4. To ascertain the effect of continuous electrical stress on the paint coating in the presence of moisture the cone was filled with tapwater, or other electrolyte as desired, and a continuous electrical potential of four volts applied by attaching one terminal of a storage battery to the sheet iron of the cone and the other to a small copper electrode placed in the tapwater but not touching the paint. This subjects the paints to practically the same conditions as those which prevail with pipe coatings in actual service where there is a difference of potential between pipes and ground, the four volts used in the tests being a value frequently met with in practice. In testing each paint two specimens were made. In one of these the iron was maintained positive and in the other negative so that the behavior of the paint with current tending to flow both to and from the iron could be determined. The term "breakdown" as used in connection with this test means the appearance of a failure in the coating of paint

which allowed a measurable current to pass. The measurements of current were made with a mil-ammeter having a total scale reading of 0.0015 amperes or 0.00001 ampere per scale division. The specimens were left in circuit long enough after breakdown to determine definitely that the current was passing through the coating and not creeping over the edge of the cone.

It seems improbable that any coating of paint which withstood test No. 1 successfully would contain any flaws or pinholes. Any weakness which developed later could reasonably be supposed, therefore, to be inherent in the paint itself. As to test No. 4 it can not be said that this is too severe in view of the conditions imposed upon paint coatings in practice where electrolysis conditions prevail, but on the contrary conditions even more severe than this are often encountered under service conditions. It follows therefore that those paints which have failed under these tests cannot be relied upon as a protection against electrolysis.

The results of the tests to date are shown in Table III. Out of the 16 different kinds of paints and pipe dips thus far tested, using 40 specimens, but one seems to be holding out for any considerable length of time even under the mild conditions of the test. This is specimen 2 of paint No. 3 which has not yet failed.

The first failure occurs in a single spot, raising a blister and, in the case of the anode, rapidly eating a pit in the metal. If the specimen is left in circuit with constant voltage applied the coating ultimately breaks down in other spots and the pitting extends over the entire surface.

The failure of the coatings is strikingly shown in Fig. 3 which shows photographs of three typical specimens. The two outside specimens have both been subjected to a pressure of four volts, one as anode and the other as cathode, while the specimen in the middle coated with the same paint was merely immersed in the electrolyte during the same period without any difference of potential being applied. The latter

TABLE III.

Paint number	Cone number	Number of coats	Res. in ohms per sq. cm.	Solution in cone	Volts of time test	Polarity of cone	Hours to breakdown
1	1	4	72×10^{11}	2% Na_2CO_3	4	Positive	312
	2	4	72×10^{11}	Tapwater	4	Positive	384
2	1	4	72×10^{11}	2% Na_2CO_3	4	Positive	192
	2	4	1.6×10^{9}	Tapwater	4	Positive	0
3	1	4	72×10^{11}	½% H_2SO_4	4	Positive	312
	2*	4	72×10^{11}	Tapwater	4	Positive	See foot-note
4	1	4	3×10^{10}	½% H_2SO_4	4	Positive	528
	2	4		Failed under 80 volts			
	3[1]	5	3.6×10^{10}	Tapwater	4	Positive	See foot-note
5	1	5	7×10^{9}	3½ NaCl	4	Positive	840
	2	5	3.2×10^{9}	Tapwater	4	Positive	120
6	1	5	10.8×10^{9}	2% Na_2CO_3	4	Positive	5
	2	5	3.2×10^{9}	Tapwater	4	Positive	7
7	1	4	1.7×10^{9}	2% Na_2CO_3	4	Positive	5
	2	4	7.7×10^{8}	Tapwater	4	Positive	240
8	1	4	2×10^{11}	½% H_2SO_4	4	Positive	5
	2	4	5.5×10^{10}	Tapwater	4	Positive	552
9	1	4	4.5×10^{8}	Tapwater	4	Positive	384
	2	4	3.6×10^{8}	Tapwater	4	Positive	0
10	1	4	1.2×10^{9}	Tapwater	4	Positive	0
	2	5	2×10^{11}	Tapwater	4	Positive	668

* No break to date or 1,680 hours.
1 No break to date or 648 hours.

TABLE III.—(*Continued.*)

Paint number	Cone number	Number of coats	Res. in ohms per sq. cm.	Solution in cone	Volts of time test	Polarity of cone	Hours to breakdown
11	1	4	1×10^9	Tapwater	4	Positive	7
	2	4	6.6×10^9	Tapwater	4	Positive	30
12	1	4	1×10^{10}	Tapwater	4	Positive	7
	2	4	Failed under 80 volts				
	3	5	Failed under 80 volts				
13	1	Pipe dip	2.8×10^{10}	Tapwater	4	Positive	7
	2	Pipe dip	2×10^{11}	Tapwater	4	Positive	7
	3	Pipe dip	2×10^{11}	Tapwater	4	Positive	96
	4[1]	Pipe dip	2×10^{11}	Tapwater	4	Positive	See foot-note
14	1[2]	3 layers treated felt & composition	2×10^{11}	Tapwater	4	Positive	See foot-note
15	1[3]	3 layers treated felt & composition	2×10^{11}	Tapwater	4	Positive	See foot-note
16	1	4	3×10^9	2% Na_2CO_3	4	Positive	24
	2[4]	5	1.6×10^9	Tapwater	4	Positive	See foot-note
	3	4		Failed under 80 volts			
17	1	4		Failed under 80 volts			
	2	5	2.2×10^9	Tapwater	4	Positive	48
	3	5					
18	1	5	9×10^7	Tapwater	4	Positive	48
19	3	4	1.6×10^9	Tapwater	4	Negative	216
20	3	3	5.6×10^9	Tapwater	4	Negative	192

[1] No break to date or 668 hours. [2] No break to date or 1,904 hours. [3] No break to date or 1,904 hours.
[4] No break to date or 668 hours.

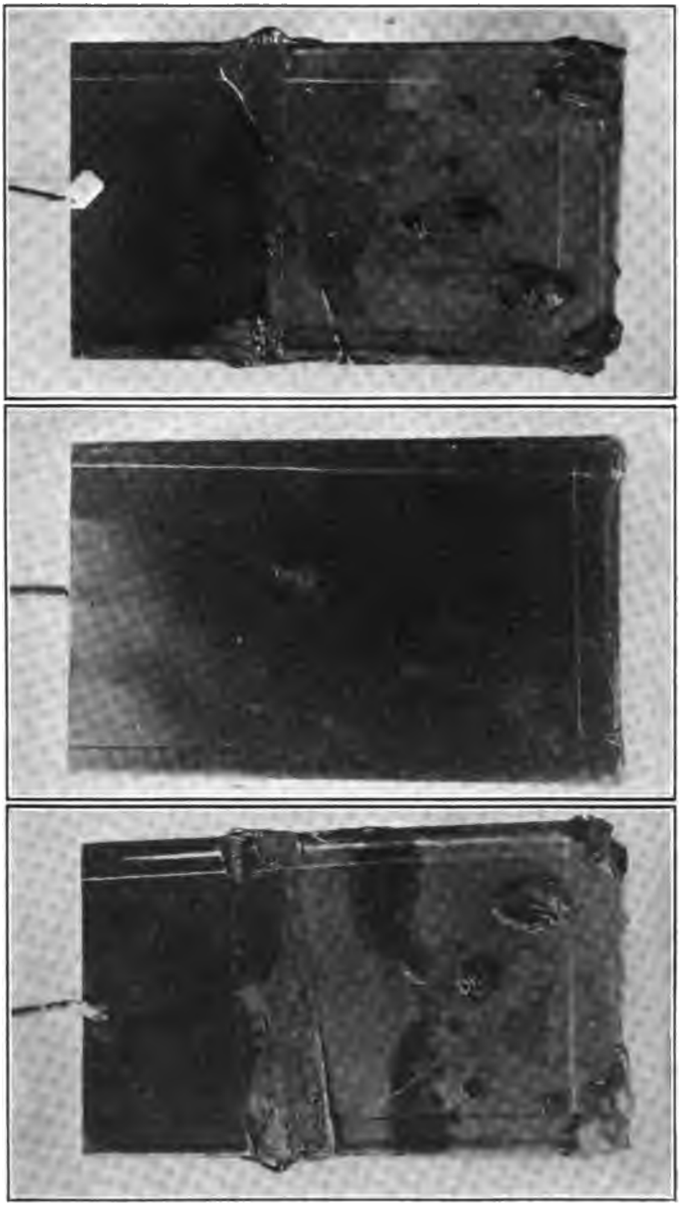


Fig. 3.

appears to be in perfect condition whereas the other two are completely destroyed. The explanation of the phenomena lies in the fact that none of the paints tested are absolutely impervious to moisture, and when brought into the presence of water a slight trace of moisture ultimately penetrates clear through the coating. When this occurs the coating becomes slightly conducting at that point and if an electromotive force is applied a trace of current flows at first, giving rise to slight electrolysis, which is accompanied by the formation of more or less gas beneath the coating. As this gas increases in amount and expands the coating is ruptured, after which the flow of current is greatly increased at the point of breakdown and rapid electrolysis of the exposed iron follows. In some cases, if the coating is sufficiently porous to permit the gases to escape it may remain intact and electrolysis may continue beneath the coating eating clear through the metal without any superficial evidence of failure of the paint. This phenomenon is frequently met with in practice. The vital weakness of all the paints thus far tested is due to this single fact that none of them are entirely non-absorbent. If a paint could be secured which was absolutely impervious to soil moisture and which would remain so for an indefinite period, it would prove an effective preventative of electrolysis, and all efforts to produce such a protective paint should be directed to this one point of making it absolutely and permanently moist proof.

Many manufacturers of paints now on the market claim that their product is entirely moisture proof and will often present elaborate experimental data in support of their contention. In practically all cases, however, these tests, while sufficient to show that the paints possess considerable power to resist moisture, are not sufficiently delicate to determine whether or not they are capable of meeting the severe conditions required in protecting pipes from electrolysis. The electrical test carried out as described above is an extremely sensitive one, and is the most reliable test with which we are acquainted for determining the value of a paint as a protection

against electrolysis, and any paint that will not endure under this test for many months at least, should not be relied upon for this purpose.

The manner in which these paints usually fail under electric stress shows that they may under certain circumstances increase the trouble from electrolytic action. Breaking down as they do at isolated points the discharge of current from the pipes is concentrated at those points and the pitting is likely to be more serious than if the paint were not used at all. In all areas, therefore, where the pipes are strongly positive to earth these paints are likely to do more harm than good and it would be better to omit them altogether. In places where the pipes are practically neutral, or negative to earth they can do no harm even if they do fail in spots and in such places they may be of value in reducing the flow of current in the pipes and in preventing soil corrosion.

Another method of insulating pipes that has frequently been used is by the application of treated papers or textiles to the surface of the pipes. A complete series of tests of such materials is planned and some of the tests are now under way, but in most cases they have not proceeded far enough to yield positive results although it may be said that in most cases the results to date are very much more promising than those obtained with paints and dips. This is doubtless due mainly to the fact that a better and more uniform coating can be obtained with these materials. Specimens No. 14 and 15 of the table belong to this class. Some experiments which we have had in progress for some time in connection with the waterproofing of concrete are of interest here.

Concrete specimens waterproofed with three and five layers of felt treated with asphalt and interspersed with layers of asphalt compounds, after standing in water for four months show no sign of electrical conductivity through the coating and the absorption of water has been extremely slow. With two layers of the felt and compound slight conductivity has developed in two specimens out of a total of eight. These coatings have been subjected to an electrical stress of 15 volts

continuously. The average absorption for those specimens waterproofed with three layers of the felt compounds has been 53 grams per square foot of surface. Forty-one grams of this were taken up during the first two months of the test and twelve during the last two. These tests show that they slowly absorb moisture, so that it seems altogether probable that their failure is only a question of time. The thicker such coatings are made the longer will be the time required for trouble to develop, and in certain cases where the cost is not prohibitive it may be possible to protect the pipes for a considerable time by the application of a sufficiently heavy coating. This has been accomplished in some cases where the pipes have been laid in a trough and the trough poured full of pitch. If a good grade of pitch and a sufficiently thick wall be used the pipe may be protected for several years, but the protection should at best be regarded as a temporary one until further and more favorable experimental data are obtained.

These tests are to be continued until all available paints, dips, and wrappings that are recommended for the protection of pipes have been thoroughly tested. In the meantime if any manufacturer, or any engineer has obtained results with these coatings differing from those given above we should be glad to be informed of the fact and to make a full investigation of the cause of the discrepancy.

Another method of reducing current flow in pipes and one which has found extensive application within the last few years, is that of breaking up the continuity of pipe lines by the use of insulating or resistance joints. In ordinary wrought iron or steel mains with screwed or riveted joints the resistance of the joints is usually small in comparison with that of the pipes, and when such pipes are laid in localities where there is an appreciable potential gradient in the direction of the pipe, currents of considerable magnitude will usually be carried by the pipes. In the case of cast iron mains using lead joints, the resistance of the joint is often as great or greater than that of a section of pipe, and it is not uncommon to find a lead joint having a resistance equal

to that of several hundred feet of pipe, and it is due largely to this fact and to the higher electrical resistance of cast iron, that such pipes carry considerably less current under similar conditions than wrought iron or steel pipe. The frequent injury to cast iron pipes by electrolysis has shown, however, that the resistance of lead joints is far too small to reduce the current to a safe value even under ordinarily severe conditions. Attempts were therefore made to still further reduce the current in the pipes by the introduction of specially designed joints of high resistance.

Following the earlier attempts to prevent electrolysis by this method very strongly claims were made for it by some of its advocates, some of them claiming that they had completely solved the problem by the use of insulating joints. Within a few years, however, a noticeable reaction set in, many engineers criticising the method, and some of those who were its warmest advocates in the beginning abandoned it. It is but natural however that the initial attempts to apply this method should have resulted in some disappointments and it is not safe to consider these early failures too seriously in judging the value of the method when properly applied. At that time no experience had been gained in regard to the frequency with which such joints should be used, the proper location of the joints, the kinds of joints best suited to certain conditions, and the complications arising from the presence of other pipe systems not so insulated. All these are important factors and must be carefully considered if the maximum of protection is to be secured at a minimum cost. Despite the criticism it has received in some quarters, the method has steadily gained in favor, and is more frequently encountered at the present time than ever before.

A number of cases have come to our attention where systems in which insulating joints have been installed have, nevertheless, suffered severely from electrolysis. In every case that we have examined, however, there has been good reason for believing that the trouble was due either to the use of an insufficient number of joints, or to the fact that they

were not located in such places as to be most effective in reducing danger. A very common procedure has been to place, in a pipe line running at right angles to the track, a single insulating joint on either side of the track and a few feet therefrom, and to assume that this insulating joint should prevent current from getting from the railway tracks into the pipes, beyond the joint. The reason why this might fail to protect the pipes in many instances can be seen by reference to Fig. 4 in which the dotted lines and arrows indicate

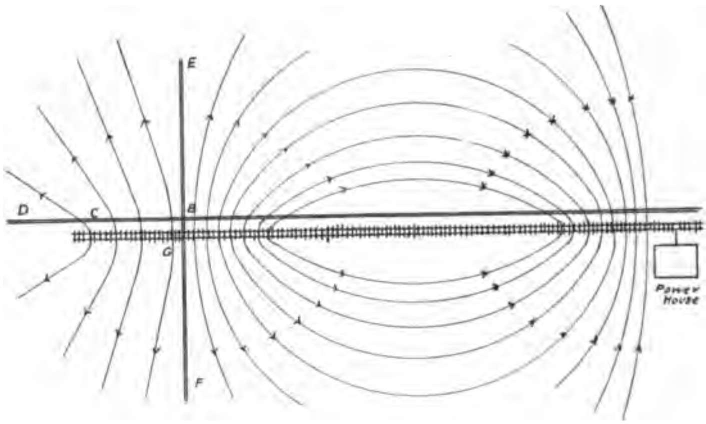


Fig. 4

the general direction of the flow of current in the earth in the case of a simple straight line railway free from any complicating circumstances such as pipe systems, nearby railways, etc. and in which the load is assumed to be well out toward the farther end of the line. It will be seen that at points near the power house, current tends to flow into the tracks from the surrounding earth and at the farther end of the line the current tends to flow radially outward in all directions, at the extreme end of the line the direction of current flow being in a direction away from the power-house. If we measure potential gradients in the region indicated by B, E, F, C, D, we find that very considerable potential differences exist

between different points of the earth, as between G and E, or between C and D. As a rule when track conditions are good these potential differences will be high only near the track, becoming quite small at distances of fifty or a hundred feet or more from the track. Under some circumstances, however, as with heavy loads, or with a bad condition of the track between A and B, potential gradients of considerable magnitude may exist between points located at a considerable distance from the track, as for example between B and E. An insulating joint placed at B will of course reduce greatly the current that will flow in the pipe from A to E, and if the potential gradients are small enough the single joint at B may be sufficient to reduce the current to a value that will do no harm. If however, due to any of a number of conditions that may arise in practice, the potential gradients in the earth should not be low, there may be sufficient difference of potential between the points B and E to cause considerable current to be picked up by that portion of the pipe and thus give rise to electrolysis in the region beyond the joint B. Similarly between C and D we may have, at points entirely beyond the terminus of the railway system, the condition of currents flowing in the pipes away from the power-house, even though an insulating joint may be placed at C, and if conditions at points beyond D should be such as to cause this current to be discharged locally serious electrolysis might occur at points remote from and entirely beyond the range of the system. The mere fact, however, that insulating joints at the points B and C will not entirely prevent such conditions from arising is no valid evidence that such joints are of no value, although they have often been condemned because electrolysis has occurred under conditions exactly similar to those outlined above. It simply means that after the joints at B and C were installed, there still remained extensive areas where pipes were laid in soils in which there were considerable potential gradients parallel to the pipes. There being no insulating joints in those areas currents must inevitably flow in the pipes. If a suitable number of insulating joints had

been properly distributed between B and E and between C and D these currents could have been kept down to any desired value and the trouble avoided.

In determining by actual experiment under practical conditions just how effective insulating joints may be in reducing currents in pipes it would be very desirable to select a particular installation and make a complete survey of the system, including current measurements in the pipes, and then install, at points indicated by the survey, a complete system of insulating joints, after which the current measurements in the pipes could be repeated, and thus unquestionable data be obtained as to the effect of the insulating joints on the current flow. We have not as yet been able to carry out a test of this sort, but it is hoped that in the near future arrangements can be made for carrying out an investigation of this kind under actual conditions. We have, however, in connection with other lines of field work, made excavations and measured the flow of current in pipe lines provided with insulating joints at more or less frequent intervals, and by comparing these with similar measurements on lines not provided with insulating joints but otherwise similarly situated a good general idea may be gained as to the extent to which the currents are reduced by the joints. In making such measurements the method used was the one most commonly employed by engineers for this purpose, viz. to expose a portion of the pipes between adjacent joints and with a milli-voltmeter measure the drop of potential between two points a measured distance apart. The size, type and class of pipe being known, and the specific resistance being obtained from tables prepared for this purpose, the current in the pipe could be calculated with a sufficient degree of accuracy for work of this kind. If it were desired to repeat readings after the excavations were filled, permanent contacts were made by sawing a slot in the pipe about 1/16 inch deep with a hack saw and riveting the end of a No. 16 rubber covered wire into the slot, the other end being brought to the surface for connection to the milli-voltmeter when desired. The

junction between copper and iron should be carefully covered with paraffin, pitch or other insulating material to protect the junction from corrosion.

Wherever practicable the current measurements were made in cities where one pipe system only, either water or gas, was provided with insulating joints, and by selecting places where the pipes of the two systems lay parallel and near together for some distance it was possible to obtain points at which the two systems were subjected to similar conditions except for the insulating joints, and in this way a fairly definite idea of the effect of insulating joints could be obtained. Such readings are of course not altogether satisfactory for there was often a difference in the material of the pipe and also in some cases, a difference in size, and allowance should be made for these. There was also the uncertainty in regard to the ramifications of the network to which the lines were connected, but in general the conditions were sufficiently similar to indicate clearly the effect of the joints.

A number of these current readings in parallel mains is shown in Table IV. In test No. 1, made in Wilkinsburg, the measurements were taken on an 8 inch water main provided with an isolated leadite joint and on the same street measurements were taken on a 6 inch gas main provided with lead joints throughout. As shown in the table, the current in the former was 0.6 ampere and in the latter 1.37 amperes, showing an appreciable reduction, although the difference is small. It is important to note, however, that in this case the leadite joints were at a considerable distance apart, averaging several thousand feet, and further they were not installed with the idea of making them insulating so that in many cases the joints were of low resistance owing to contact between the bell and spigot ends of the pipes. In test No. 2 measurements were taken on a 12 inch main provided with a leadite joint every twelve feet, and on a parallel 16 inch main with lead joints throughout. The difference here is very marked, the current in the lead jointed line being over eighty times that in the

TABLE IV.—CURRENTS FLOW IN PARALLEL MAINS.

	City	Mains			Type of joint	Distribution of insulating joints in mains	Section in which drop was measured		Average potential across section millivolts	Amp. in pipe
		Type	Class	Size inches			Distance to joint	Length feet		
1	Wilkinsburg	Cast	D	8	Leadite	Insolat.	Adj.	9	0.2	0.6
	Wilkinsburg	Cast	A	6	Lead	None		6	0.4	1.37
2	Wilkinsburg	Cast	A	12	Leadite	12 ft.	Adj.	11½	0.013	0.65
	Wilkinsburg	Cast	C	16	Lead	None		3	0.2	5.55
3	Wilkinsburg	Cast	D	12	Leadite	12 ft.	Adj.	10½	0.013	0.72
	Wilkinsburg	Cast	C	16	Lead	None		8	0.83	8.66
4	Wilkinsburg	Cast	D	12	Leadite	300 ft.	Adj.	11	0.02	0.106
	Wilkinsburg	Cast	C	4	Lead	None		6	0.3	0.695
5	Erie	Wrot	Stan.	6	No. 6 D	Insolat.	Adj.	3	0.005	0.167
	Erie	Cast	C	6	Lead	None		3½	0.8	4.6
6	Erie	Wrot	Stan.	4	No. 6 D	Irreg.	Adj.	2¼	0.01	0.26
	Erie	Cast	C	4	Lead	None		10¾	8.0	12.8
7	Erie	Wrot	Stan.	6	No. 6 D	Irreg.	Adj.	3	0.0025	0.086
	Erie	Cast	C	20	Lead	None		10½	1.9	22.6
8	Erie	Wrot	Stan.	4	No. 6 D	Irreg.	Adj.	2½	0.01	0.236
	Erie	Cast	C	4	Lead	None		7	0.15	0.3
9	Erie	Wrot	Stan.	6	No. 6 D	Irreg.	Adj.	1⅓	$<$0.0025	$<$0.196
	Erie	Cast	C	6	Lead	None		11⅙	0.02	0.75
10	Erie	Wrot	Stan.	8	No. 6 D	Irreg.	Adj.	2½	$<$0.0025	$<$0.156
	Erie	Cast	C	6	Lead	None		11¾	2.4	4.4
11	Erie	Wrot	Stan.	3	No. 39 D	20 ft.	Adj.	22	0.005	0.108
	Erie	Cast	C	6	Lead	None		10½	2.0	3.9
12	Ashtabula	Wrot	Stan.	3	No. 6 D	Irreg.	1,000	10	1.2	$<$0.0125
	Ashtabula	Cast	C	10	Lead	None		10	0.3	1.29
13	Ashtabula	Wrot	Stan.	3	No. 6 D	Irreg.	1,300	4	—0.01	—0.104
	Ashtabula	Cast	C	12	Lead	None		10	0.5	2.91
	Ashtabula	Cast	C	12	Load	None		10	0.2	1.16
14	Ashtabula	Wrot	Stan.	3	No. 6 D	Irreg.	500	10	0.015	0.62
	Ashtabula	Cast	C	10	Lead	None		10	5.0	21.5

line having leadite in every joint. Similarly in test No. 3 where also one line was provided with a leadite joint every twelve feet, the difference is even more marked, in the current in the case of lead joints being about a hundred and twenty times, that in the pipes having leadite joints. In test No. 4 the difference is much less, but this is partly due, no doubt, to the difference in size of the pipes as shown by the table. The chief factor, however, is the distance between the leadite joints, this being in the present instance about three hundred feet.

Tests No. 5 to 11 inclusive were made in Erie, Pa., on wrought iron gas mains provided with Dresser couplings at irregular intervals and on parallel cast iron water mains provided with lead joints. In comparing these figures it should be borne in mind that cast iron has a much higher resistance than wrought iron, and further that the lead joints themselves introduce considerable resistance into the circuit, so that the real effect of the Dresser joints is much greater than the figures would indicate. While considerable variation exists in the ratios of current in parallel mains in the different tests of this series, they show without exception considerable reduction in current due to the insulating joints. Taking the average of the six tests of this series we find that the current in the lines having lead joints averaged about fifty-eight times that in the lines having insulating joints. In all of these cases except in test No. 11, the insulating joints were irregularly spaced the distance between joints in various parts of the system varying from three hundred to several thousand feet. This fact being considered, the relatively low values of current in the lines provided with insulating joints is quite remarkable. In the last three tests shown in Table IV, Nos. 12, 13 and 14, the ratios of current in the lead jointed lines to that in the lines with insulating joints is respectively 103, 28, and 346. but in these tests considerable allowance must be made for the relatively large size of the cast iron mains as shown by the table. A remarkable feature of test No. 13 was that the direction

TABLE V.—SMALL CURRENTS FLOWING IN MAINS PROTECTED BY INSULATING JOINTS.

City	Mains			Joints		Distribution of insulating joints in mains feet	Section in which drop was measured		Average potential across section millivolts	Amperes in pipe
	Kind	Class	Size inches	Age years	Kind		Distance from insul. joints, ft.	Length feet		
Wilkinsburg....	Cast	D	12	3	Leadite	12	Adj.	12	0.013	0.065
Wilkinsburg....	Cast	D	12	3	Leadite	12	Adj.	10½	0.013	0.072
Wilkinsburg....	Cast	D	12	3	Leadite	12	Adj.	11	0.013	0.164
Wilkinsburg....	Cast	D	12	2	Leadite	12	Adj.	8	0.01	0.073
Wilkinsburg....	Cast	D	12	2	Leadite	12	Adj.	11	0.041	0.217
Wilkinsburg....	Cast	D	12	3	Leadite	12	Adj.	11	0.01	0.053
Wilkinsburg....	Cast	D	12	4	Leadite	Isolat.	Adj.	10¼	0.02	0.112
Wilkinsburg....	Cast	D	12	4	Leadite	300	Adj.	11	0.02	0.106
Wilkinsburg....	Cast	D	12	3	Wood	Isolat.	Adj.	6	0.01	0.10
Wilkinsburg....	Cast	D	12	3	Wood	Isolat.	100	6	0.03	0.30
Erie............	Wrot	Stan.	4	4	No. 6 D	20	Adj.	8	<0.0025	<0.0215
Erie............	Wrot	Stan.	6	4	No. 6 D	Isolat.	Adj.	3	0.005	0.167
Erie............	Wrot	Stan.	4	4	No. 6 D	Irreg.	Adj.	225	0.01	0.26
Erie............	Wrot	Stan.	6	4	No. 6 D	Irreg.	Adj.	3	0.0025	0.086
Erie............	Wrot	Stan.	4	4	No. 6 D	Irreg.	Adj.	2½	0.01	0.236
Erie............	Wrot	Stan.	6	4	No. 6 D	Irreg.	Adj.	1⅓	<0.0025	<0.196
Erie............	Wrot	Stan.	8	4	No. 6 D	Irreg.	Adj.	2½	<0.0025	<0.156
Erie............	Wrot	Stan.	3	4	No. 39 D	20	Adj.	2⅙	0.005	0.108
Ashtabula	Wrot	Stan.	3	2	No. 6 D	Irreg.	1000	10	<0.0025	<0.0125
Ashtabula	Wrot	Stan.	3	2	No. 6 D	Irreg.	1300	4	—0.01	—0.104
Ashtabula	Wrot	Stan.	4	2	No. 6 D	Irreg.	200	10	0.015	0.088
Ashtabula	Wrot	Stan.	4	2	No. 6 D	Irreg.	Adj.	3	0.025	0.075
Ashtabula	Wrot	Stan.	4	2	No. 6 D	Irreg.	1200	6	0.02	0.197
Ashtabula	Wrot	Stan.	4	2	No. 6 D	Irreg.	600	6	0.01	0.098
Ashtabula	Wrot	Stan.	4	2	No. 6 D	Irreg.	Adj.	4	0.0025	0.037
Ashtabula	Cast	C	6	2	No. 6 D	Irreg.	Adj.	3½	0.01	0.0595
Ashtabula	Wrot	Stan.	3	2	No. 6 D	Irreg.	500	10	0.015	0.062
Ashtabula	Cast	C	8	2	No. 6 D	Irreg.	2500	6	0.2	0.09
Ashtabula	Wrot	Stan.	4	2	No. 6 D	Irreg.	750	6	0.1	0.098
Ashtabula	Cast	C	6	10	Cement	12	Adj.	11	0.0025	0.005
Ashtabula	Cast	C	6	10	Cement	12	Adj.	11	0.015	0.028
Ashtabbla	Cast	C	6	10	Cement	12	Adj.	11	0.05	0.095

of flow of the current in the gas line having insulating joints was opposite to that in the lead jointed line. This is due no doubt, to the fact that the gas main was discharging current into the water network occupying the same district as an insulated one may give rise to abnormal local conditions which may tend to cause trouble to the insulated line.

In Table V is shown a series of current measurements on lines having insulating joints under conditions where, in most cases, it was not possible to obtain similar readings on lines not so insulated, and they are presented here merely to show that in general these currents have been found to be very low. These figures may be regarded as typical of what may be expected under ordinary conditions where a considerable number of insulating joints are used. That the current in these systems were not invariably small, however, is shown in Table VI, which gives a number of tests showing currents of considerable magnitude flowing in the pipes. It is to be noted however that in all such cases the insulating joints were widely separated as shown by the column giving the distance from the nearest insulating joint to the point at which the measurements were taken. The distance between joints being at least double these values, they range therefore from four hundred to several thousand feet. These figures simply emphasize the fact pointed out above that if the joints are placed too far apart in places where potential gradients in the earth are high, dangerous currents may be taken up by the pipes.

In all of the cases above referred to the resistance joints were either spaced at considerable distances apart, or were not carefully made so as to insure a high resistance, and they do not therefore show what may be accomplished by the use of insulating joints when installed at very frequent intervals and when proper care is taken to eliminate defects in the joints. In order to secure further and more exact data on this point two experimental lines of 4 in. cast iron pipe were laid at the Bureau of Standards under conditions which in-

TABLE VI.—CURRENT MAINS IN MAINS WHEN JOINTS ARE INFREQUENT.

City	Mains			Joints		Distribution of insulating in mains	Section in which drop was measured		Average potential across section millivolts	Amp. in pipe
	Type	Class	Size inches	Type	Age years		Distance from insul. joints, feet	Length feet		
Wilkinsburg......	Cast	D	8	Leadite	4	Isol.	Adj.	9	0.2	0.6
Wilkinsburg......	Cast	C	30	Leadite	3	Isol.	Adj.	11	0.2	4.08
Erie	Wrot	Stan.	6	No. 6 D	4	Irreg.	1,000	3	0.04	1.39
Erie	Wrot	Stan.	6	No. 6 D	4	Irreg.	600	2¼	0.25	8.5
Erie	Wrot	Stan.	4	No. 6 D	4	Irreg.	300	2	0.11	3.24
Ashtabula........	Wrot	Stan.	4	No. 6 D	2	Irreg.	200	19	1.0	3.1
Ashtabula........	Wrot	Casing	5⅝	No. 6 D	2	Irreg.	2,500	6	0.05	0.78
Ashtabula........	Wrot	Stan.	6	No. 6 D	2	Irreg.	1,200	2	0.4	2.08
Ashtabula	Wort	Stan.	8	No. 6 D	2	Irreg.	300	3	0.6	3.12
Ashtabula........	Wrot	Stan.	4	No. 6 D	2	Irreg.	1,200	2½	0.4	0.25

sured identical conditions except for the joints. The lines were laid parallel, one hundred feet long, and forty feet apart, one line being provided with ordinary lead joints, and the other with carefully made cement joints. The arrangements of these pipes is shown in Fig. 5. At the center of each line the pipes were separated by a large insulating plate and to the ends of the pipes adjoining this plate, insulated leads were attached, and these were brought to the surface and short circuited, an ammeter being inserted in these leads when it was desired to measure the current in the pipes. A difference of potential of 15 volts was impressed on the pipes and measurements of the current flowing in the pipes were made. The data are given in Table VII. The results are a most striking illustration of the effect of carefully installed insulating joints in keeping currents off the pipes. It will be seen that the currents flowing in the line provided with cement joints is at present less than one twenty-two thousandth part of that flowing in the line having lead joints and is decreasing. This current is so small as to be entirely negligible in so far as electrolysis effects are concerned.

TABLE VII.—CURRENT IN PARALLEL CEMENT AND LEADITE LINES.

Date	Voltage	Current amp. Cement	Lead	Ratio L/C
May 8.............	15	0.0032	29.1	9,100
Nov. 2.............	15	0.0011	24.2	22,000

It is very important to note that in the system mentioned above, not only have the currents in the pipes been reduced to relatively small values by means of insulating joints, but the systems thus protected have been singularly free from electrolysis troubles since the joints were installed. Although they have been in service for periods varying from two to ten years or longer no serious cases of trouble have arisen, although in some instances other systems laid in the same streets and not so protected have suffered considerable damage from electrolysis. Very significant in this connection also is the experience of the Cambridge Gas Co., of Cambridge, Mass. This company uses cement joints exclusively in

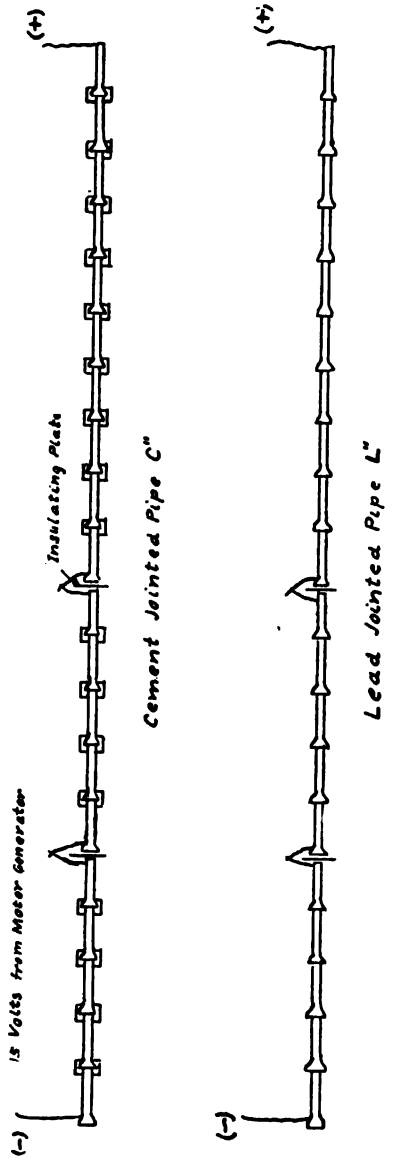

(+)
(+)
Insulating Plate
15 Volts from Motor Generator
(−)
(−)
Cement Jointed Pipe C"
Lead Jointed Pipe L"

Fig. 5

their gas mains and they have had no appreciable trouble from electrolysis, while the water pipes occupying the same region and not so protected have suffered severely for years.

While the foregoing shows that insulating or resistance joints when properly installed and used in sufficient number will very greatly reduce the flow of current in pipes, there are certain features in connection with such installations, which, if not guarded against may give rise to considerable trouble. In the first place joints designed and installed as insulating joints may or may not be insulating when completed, and this is especially apt to be true after the joints have been in service for a considerable length of time. A little carelessness in making the joint may permit the two ends of the pipe to make metallic contact, in which case, of course the joint becomes worthless as a protection against electrolysis. This is particularly apt to occur in making joints where cement or leadite is substituted for lead, but it can easily be guarded against with a little care. But even when every care is exercised in making the joints, they will often show surprisingly low resistances after having been in service for a considerable time. Table VIII shows the resistances of a number of so-called insulating joints in actual service selected at random and these are typical of what may be expected. In measuring these resistances a joint and a portion of the pipe were uncovered and the drop across the joint compared with that across a measured length of pipe either by means of a voltmeter or with a slide wire bridge. The size, weight and material of the pipe being known the resistance of both pipe and joint in ohms could also be calculated with a fair degree of accuracy. It is to be noted that a number of joints show an extremely low resistance, comparable with that of an ordinary lead joint, thereby indicating metallic contact of the pipes. This is particularly true of some of the leadite joints. It is important to note that the leadite joints were made without any attempt to make them insulating and this is largely responsible for the large proportion of very low resistance joints. Perhaps the

TABLE VIII.—RESISTANCE JOINTS.

	Mains			Joints			Resistance of joint	
City	Kind	Class	Size inches	Type	Age years	Average potential across joint millivolts	Ohms	Length of pipe with same resistance feet
Wilkinsburg.......	Cast	D	8	Leadite	4	0.8	0.00133	36
Wilkinsburg.......	Cast	D	8	Leadite	4	20.	0.033	900
Wilkinsburg.......	Cast	D	12	Leadite	3	8.	0.123	7,100
Wilkinsburg.......	Cast	D	12	Leadite	3	0.02	0.0003	75
Wilkinsburg.......	Cast	D	12	Leadite	3	0.3	0.004	241
Wilkinsburg.......	Cast	D	12	Leadite	3	1.	0.014	810
Wilkinsburg.......	Cast	D	12	Leadite	3	5.	0.03	1,770
Wilkinsburg.......	Cast	D	12	Leadite	3	5.	0.03	1,770
Wilkinsburg.......	Cast	D	12	Leadite	2	0.15	0.002	120
Wilkinsburg.......	Cast	D	12	Leadite	2	4.	0.018	1,100
Wilkinsburg.......	Cast	D	12	Leadite	2	11.	0.051	3,000
Wilkinsburg.......	Cast	C	30	Leadite	3	60.	0.015	3,300
Wilkinsburg.......	Cast	C	30	Leadite	3	5.	0.0012	275
Wilkinsburg.......	Cast	D	12	Leadite	3	3.	0.0052	315
Wilkinsburg.......	Cast	D	12	Leadite	3	3.	0.0052	315
Wilkinsburg.......	Cast	D	12	Leadite	3	0.6	0.0113	660
Wilkinsburg.......	Cast	D	12	Leadite	3	0.12	0.226	13,200
Wilkinsburg.......	Cast	D	12	Leadite	4	40.00	0.357	20,600
Wilkinsburg.......	Cast	D	12	Leadite	4	30.	0.268	15,450
Wilkinsburg.......	Cast	D	12	Leadite	4	40.	0.357	20,600

TABLE VIII.—(*Continued.*)

City	Mains			Joints		Average potential across joint millivolts	Resistance of joint	
	Kind	Class	Size inches	Type	Age years		Ohms	Length of pipe with same resistance feet
Wilkinsburg.......	Cast	D	12	Leadite	4	3.	0.028	1,650
Wilkinsburg.......	Cast	D	12	Leadite	4	6.	0.057	3,300
Wilkinsburg.......	Cast	D	12	18′ wood stave	3	4000.	40.	2,400,000
Erie	Wrot	Stan.	4	No. 6 D	4	57.	>2.64	>183,000
Erie	Wrot	Stan.	6	No. 6 D	4	60.	0.36	36,000
Erie	Wrot	Stan.	4	No. 6 D	4	1300.	4.96	292,000
Erie	Wrot	Stan.	6	No. 6 D	4	400.	4.65	480,000
Erie	Wrot	Stan.	4	No. 6 D	4	100.	0.425	25,000
Erie	Wrot	Stan.	6	No. 6 D	4	800.	>5.35	>560,000
Erie	Wrot	Stan.	8	No. 6 D	4	750.	>9.	>1,400,000
Ashtabula	Wrot	Stan.	4	No. 6 D	2	400.	10.65	1,600,000
Ashtabula	Wort	Stan.	4.	No. 6 D	2	200.	9.5	560,000
Ashtabula	Cast	C	6	No. 6 D	2	80.	0.286	59,500
Ashtabula	Cast	C	6	Cement	10	0.01	0.002	44
Ashtabula	Cast	C	6	Cement	10	0.02	0.004	88
Ashtabnla	Cast	C	6	Cement	10	6.00	0.21	4,400
Ashtabula	Cast	C	6	Cement	10	0.06	0.0021	46
Ashtabula	Cast	C	6	Cement	10	13.00	0.14	2,900
Ashtabula	Cast	C	6	Cement	10	80.	16.	350,000
Ashtabula	Cast	C	6	Cement	10	20.	0.21	4,400

most surprising feature of this table is the low resistance shown by the Dresser couplings which had been in service for a number of years. Although these joints are provided with rubber gaskets and doubtless had a very high resistance when new, the resistances have now fallen to but a few ohms. A joint having a resistance of this magnitude, however, is practically as good as one of much higher resistance since only currents of negligible value can flow through such a resistance under the differences of potential that would commonly prevail across the joint in practice. In the case of the joints having a resistance of a few hundredths of an ohm or lower, currents of considerable magnitude may be found, and these cannot be regarded as satisfactory resistance joints except in pipes of very large size. With reasonable care in the making, however, all joints whether made of cement, or wood or some special joint like the Dresser or Hammon couplings will have ample resistance, and if properly located and used in a proper manner any of these joints should prove effective.

Leadite joints when new, also have ample resistance, comparing favorably with cement joints in this respect, but their resistance appears to decrease rapidly with age. This is very strikingly shown in Table IX which shows the variation of the resistance of some leadite joints with time. A pipe line

TABLE IX.—SHOWING VARIATION OF RESISTANCE OF LEADITE JOINTS WITH TIME.

Date	July 7	July 14	July 21	July 28	Aug. 11	Aug. 25	Sept. 8	Sept. 19
Current	0.0069	0.0076	0.046	0.268	0.064	0.360	1.24	1.88
Resistance	2,174	1,990	326	56	23	41	12	8—ohms

about 100 feet long was laid with leadite joints, care being taken to make all joints free from metallic contact between the ends of the pipe. At the center of the line the pipes were separated and an insulating plate inserted, and the two ends of the pipe on either side of the insulating plate were provided with insulated leads leading to the surface in which an ammeter could be inserted for the purpose of measuring the current flowing in the pipes from time to time. The arrange-

ment for measuring current was essentially the same as with the cement covered pipes shown in Fig. 1. A difference of potential of 15 volts was impressed on this line continuously which was sufficient to give a drop of potential of about 0.8 volts on each joint. The readings show that the current was very small when the pipe was first laid, but increased rapidly with time and after being laid four months the resistances have decreased to about one two thousandth of their initial value and are still decreasing. At first it was supposed that the apparent decrease in the resistance of the joints might be due to increased leakage around the joints but measurements made of some of the joints when uncovered show that the resistance of the joint itself has decreased. The resistance of these joints is still high enough, however, to be quite effective in reading currents in the pipes to a safe value under ordinarily severe conditions, but whether they will ultimately fall to so low a value as to render the joints worthless is a matter that only a long time test can show, and the tests on these joints will be continued until this point has been definitely determined.

A condition already referred to that is likely to cause trouble is a too infrequent use of insulating joints, and this condition is probably responsible for most of the disfavor into which this method has fallen in some quarters. Obviously, if the joints are placed far apart the long stretch of intervening pipe may pick up considerable current and since most of this current must flow out of the pipe as it approaches the insulating joint, serious electrolysis may occur on the positive side of the joint. The more frequently the joints are placed the less the danger from this source. It is of course impossible to lay down any very definite rules in regard to the frequency with which such joints should be used, since that must be determined in each case by local conditions. In general, however, it may be said that the resistance joints should not be confined to the positive area as some have supposed, but should be distributed throughout the negative and neutral areas also. All lines which run nearby

or cross under street railway tracks, are generally most in need of resistance joints.

In many cases where there is good reason for believing that the drop of potential is fairly uniformly distributed throughout the entire region in which the insulating joints are to be placed, it is sufficient simply to determine the total difference of potential between the ends of the line affected and use this value in determining the number of insulating joints that are needed in order that the drop of potential across each joint shall not exceed a predetermined value. It often happens, however, that the potential gradient may vary greatly in different portions of the line and if the joints were uniformily spaced in such cases, the joints would either be more frequent than necessary in some places, or too few in others, and the condition of maximum of protection at a minimum cost would not be realized. This condition is very likely to occur where a pipe line runs at right angles to railway lines in which case the potential gradient along the pipe will often be many times greater at points within a short distance on either side of the track than at more remote places. Other conditions such as the presence of other pipe systems may also disturb the uniformity of the potential drop.

In some instances as in laying new lines where some cheap type of joint is being used it may often be cheaper to allow a liberal factor of safety and install enough joints to be safe under any conditions that may arise, but in other cases, as for instance, where insulating joints are to be inserted in large and important mains already laid, where the cost of the joints is an important matter and where interruption of the service is a matter of serious moment, it is important that no unnecessary joints be used and that these be so placed that they will be most effective in reducing current flow in the pipes and so that there will be no danger of developing a high enough difference of potential across the joint to cause trouble. For this reason. before attempting to install a series of insulating joints for the purpose of preventing electrolysis in cases where it is important for economic or other reasons

to use as few joints as possible, it is important first to make a careful potential survey of the district to be affected, and determine the magnitude of the potential gradients in a direction parallel to the pipe lines. This will enable one to determine in advance the approximate number of joints that will be necessary and also the proper location of the joints so that the drop of potential across any joint may not exceed a certain amount. If a new line is to be laid it is safe to assume that the average potential gradient after the pipe has been laid will not differ greatly from that which prevails before hand, provided the joints are used at proper intervals, but the distribution of this potential gradient will be greatly altered, practically all of the fall of potential occurring at the joints. The average drop of potential across joints in any given portion of the line will be approximately equal to the total drop divided by the number of joints. When insulating joints are to be placed in old lines, it is well to bear in mind that the insertion of the joints in the pipe will, in general increase the potential gradient along the pipe. This increase may reach as much as one hundred per cent. or more and allowance should be made for this.

In actually measuring the potential gradients in the earth special precautions must be taken if trustworthy results are to be obtained. Some form of non-polarizable electrode must be used and this must be so designed that the resistance of the earth immediately surrounding the electrode will not produce a large enough drop of potential under the flow of the voltmeter current to affect seriously the readings of the instrument. To accomplish this the surface area of the non-polarizable terminal should be large and it should be used in connection with a high resistance voltmeter having a high current sensibility. A form of electrode which we have found satisfactory for this purpose is a modified form of the Haber electrode shown in Fig. 6. A wooden rod about three feet long and one inch in diameter is provided at one end with a copper sheath about six or eight inches long. To this sheath an insulated wire is connected and carried up along the rod to

be used as connection to the voltmeter. The copper sheath is then placed in a cylindrical porous enclosure somewhat

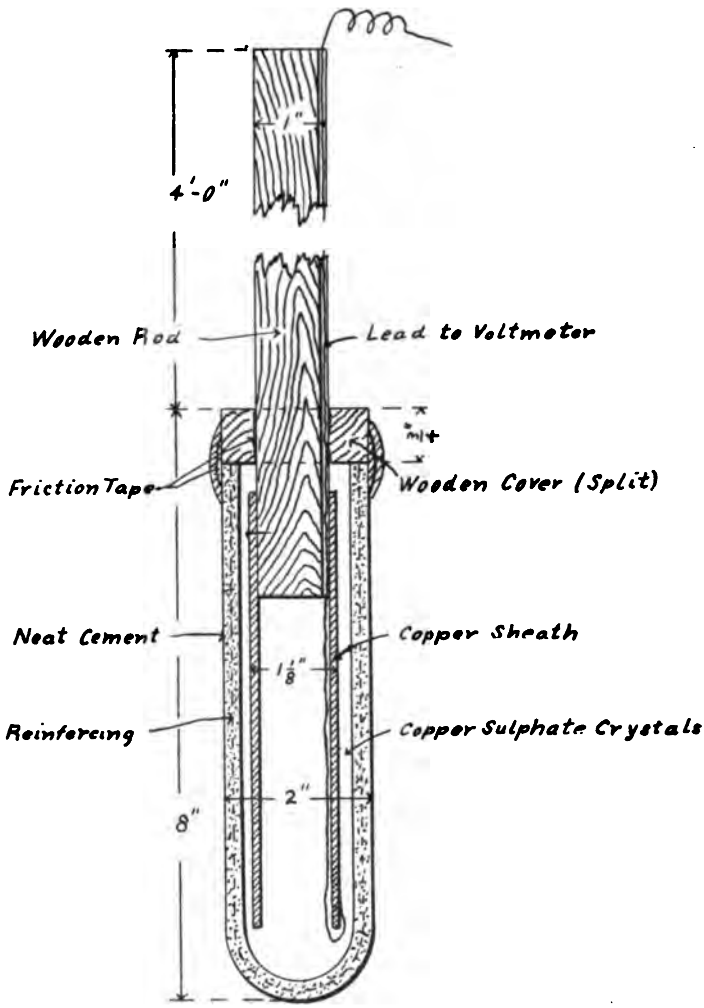


Fig 6.

larger than the sheath and the intervening space filled with copper sulphate crystals. Hollow cement cylinders about two

inches in diameter and slightly longer than the copper sheath have proven satisfactory for this purpose. Two of these electrodes are used, and when it is desired to measure the difference of potential between any two points in the earth, holes are drilled into the earth at the desired points to a depth of a foot or more by means of a crowbar or other suitable tool and these filled with copper sulphate solution or water into which the non-polarizable electrode is immersed to a depth sufficient to cover the copper sheath. The insulated copper leads being connected to the terminals of a suitable voltmeter, the difference of potential can be determined which will be practically free from errors due to polarization.

After a series of joints are installed the only method of determining experimentally whether or not a sufficient number of joints has been installed is by measuring the drop of potential across each joint and by measuring current flow in the pipes. If the joints are too few in number in any locality there will generally be too high a voltage across the joints and the consequent heavy leakage current may injure the pipe on the positive side of the joint. As to the voltage that can be safely permitted, that is a matter which depends on a variety of conditions such as the nature of the soil, kind of joint used etc. and can only be roughly indicated here. Careful observation of joints under average conditions for a considerable period together with laboratory experiments to be given later indicate that a drop across the point of from 0.1 to 0.4 volt can usually be regarded as safe. The lower limit applies to pipes located in low wet places, and to joints having a short leakage path between the sections of the pipe, and the upper limit to pipes in comparatively dry soils and to joints having a long leakage path. This matter of the length of the leakage path around the joint is an important one and is treated at some length later in discussing the relative value of different kinds of joints. If the joints used have not a very high resistance, as when leadite is used for instance, considerable current may flow through the joints without making a dangerous drop across the joint and the currents

thus collected in a large number of branch lines may ultimately be carried to a few lines in a remote quarter and there give rise to serious damage. As to whether current flowing through the leadite involves danger to the joint has not yet been determined. In order to guard against this, current measurements in the pipes should also be made. If in any line any considerable current is found to be flowing, or if the voltage across the joints exceeds considerably the limits mentioned above, additional joints should be installed.

One of the problems encountered in attempting to protect a pipe system by the use of resistance joints is the effect of other pipe systems in the same territory not so protected. Gas and water systems for instance are often brought into metallic contact with each other in many places, and this greatly increases the difficulty of protecting either system alone by the use of resistance joints. This difficulty could be largely avoided by inserting an insulating joint in the service pipe inside of the building in which metallic connection with the other system is made. There are other complications, however, which are not so easily dealt with, and where an uninsulated pipe system occupies the same territory with an insulated system isolated cases of electrolysis are like to occur.

When a line having insulated joints must be connected to another line not so insulated trouble may be experienced due to the tendency to develop with potential drops across the joints in such places, particularly if the uninsulated pipe line is at a potential considerably different from that of the earth, either positive or negative. This condition is especially likely to occur if the uninsulated main is connected to negative return feeders, and those insulating joints which connect the insulated lines to those having the negative feeders attached, are often subjected to unavoidable differences of potential that may be sufficient to destroy the joint in a short time. For this reason the use of insulating joints and negative return feeders in the same system is not to be recommended.

The difference of potential that can safely be permitted

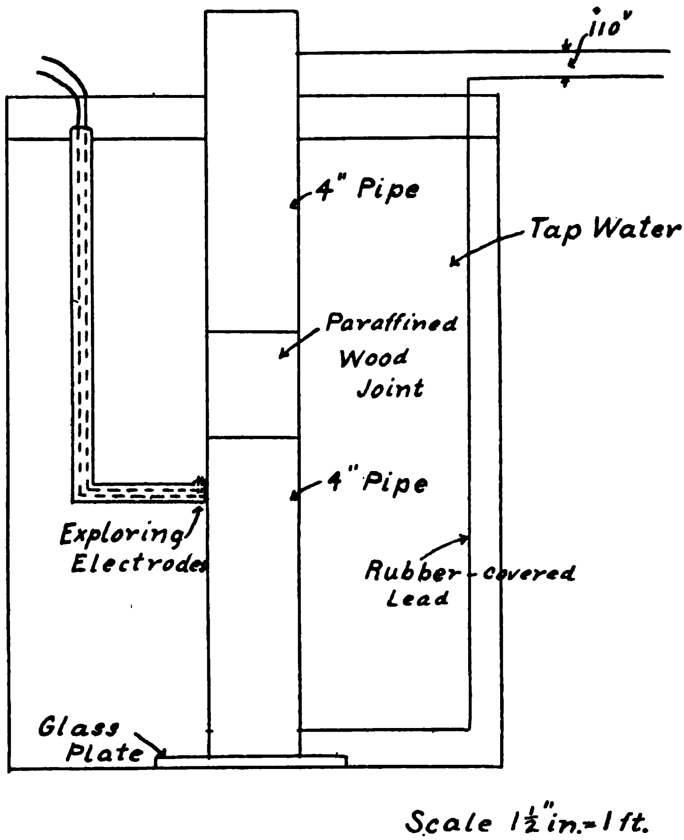
across a joint, presents a problem of great importance and one to which comparatively little study has been given. Some of the factors governing this are mentioned above and one of the most important of these is the type of joint used. It is well recognized that the actual damage due to the discharge of current from a pipe depends not so much on the total quantity of electricity discharge, but mainly on the distribution of the discharge. If the current leaves the pipe uniformly over a large surface a much longer period must elapse before serious damage will result than if the intensity of current discharge is much greater at some points than others, so that condition which tends to prevent concentration of discharge will correspondingly reduce the danger. As already shown, pipes, even when provided with insulating joints will carry some current, and especially if the joints are not very frequent, considerable current may be found, and since with high resistance joints most of this current must leave the pipes at every joint, it becomes important to determine as accurately as possible what the distribution of this discharge may be and to find how this distribution may be made most nearly uniform.

To determine something of the effect of the form of the insulating joint on the distribution of current around the joint, three perfectly insulating joints were made of 4-inch cast iron pipe, one a bell and spigot joined by paraffin, the second a butt joint with ½ inch of paraffined wood separating the pipes and the third a similar butt joint with 5 inches of paraffine wood between the pipes. The arrangement of the apparatus is shown in Fig. 7.

The pipes in succession were placed coaxially in a cylindrical tank of water 23 inches in diameter and 32 inches in depth with the joint near the center of the tank. The bottom of the tank was covered with a layer of paraffin and the end of the pipe rested on a glass plate. Rubber-covered leads attached to the pipes 14 inches from the joints permitted the impressing of voltages from 4 to 11 volts.

An L shaped, two-conductor rubber insulated cable was lowered into the water, the plane of the L being kept radial

to the pipe and the end of the L bent upward so that the line joining the exposed ends of the wires at the terminus of

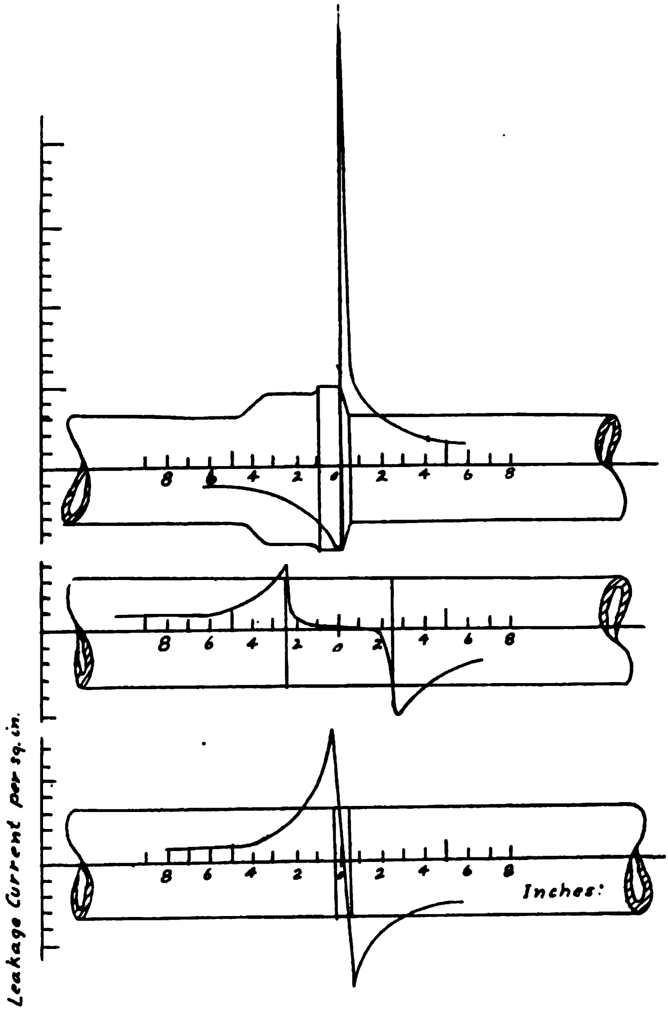


Arrangement of Apparatus for Exploring Current Distribution at Insulating Joints

Fig. 7.

the L was normal to the surface of the pipe. Since the specific resistance of the water was substantially uniform throughout, the potential gradient at any point was proportional to

the intensity of the current at that point so that by measuring the difference of potential between the two exposed ends of the wires when placed as close as practicable to the surface of the pipe (about 0.04 inch). The potential gradients thus obtained divided by the specific resistance of the water gave the intensity of current at that point, and by raising or lowering the L the intensity of current discharge at any point could be found. The specific resistance of the water used was 5,620 ohms per centimeter cube which is about the mean of that of a large number of samples of earth taken from various places in city of Pittsburg. It was necessary to impress rather high voltages across the joint in order that the potential difference between the terminals of the L should be large enough so that the reading would not be seriously affected by polarization at the terminals. From twenty to about one hundred volts were used according to the type of joint under test. The results of the tests are very strikingly shown in the curves of Fig. 8 in which the intensity of current discharge is plotted as a function of the distance along the pipe for some distance on each side of the joint. In each case the axis of the pipe is taken as the zero axis of current and positive values represent flow of current away from the pipe while negative values represent current returning to the pipe. For convenience in making comparisons all the readings are reduced to values corresponding to a difference of potential of twenty volts across the joint. The curves indicate that the form of the joint has a most decided effect on the distribution of current discharge. The bell and spigot type shows a very high density of current just under the edge of the bell indicating a very high rate of corrosion at that point. The butt joint, shown at the bottom, having a length of one-half inch shows a much better distribution of current, the maximum intensity being about one-third that in the case of the bell and spigot joint. With the joint five inches long still further reduction in the height of the peak is shown, the maximum intensity of discharge being only fifteen per cent. of that of the bell and spigot type. It is also very



Curves Showing the Effect of Various Insulating Joints on the Distribution of Leakage Current around the Joints.
Fig. 8

interesting to note that the total flow of current about the joint does not differ greatly in the three cases, the resistances of the leakage path being 68, 72 and 87 ohms in the bell and spigot, half inch and five inch joints respectively. Particularly significant is the comparison of the two butt joints in this respect. Although one is ten times as long as the other the resistance of the leakage path is increased by less than thirty per cent. This shows the unwisdom of attempting to reduce the current flow in a pipe line merely by increasing the length of a few joints. The short joints are, as a rule, much cheaper and easier to install and they can therefore be installed much more frequently for the same total cost. As a rule, therefore it would appear preferable, in installing a line of insulating joints to use a large number of short joints rather than a few long ones as in this way the current in the pipes can be kept at a much lower volume, and the relatively large number of joints will usually be sufficient to prevent any serious potential drop across the joint. In some cases, however, as where the insulating joints are discontinued, or where, for any reason, it is desired to use but a few joints, or to place them in places where high potential differences are unavoidable, the above tests show that the long joint is much to be preferred, because of its effect in preventing great concentration of current discharge near the edge of the joint.

The above data furnished also, a basis upon which can be made a roughly approximate determination of the voltage drop which may be permitted across a joint of the types tested. It can be shown that the rate at which corrosion will penetrate the iron is given by the formula

$$L = \frac{C}{D} \times \frac{P}{S}$$

where L is the rate at which the corrosion penetrates the iron expressed in centimeters per year, C is the electrochemical equivalent of iron, D its density, P the average potential gradient in volts per centimeter normal to the pipe at the point considered, and S is the specific resistance of the iron

in ohms per centimeter cube. The assumption is here made that the efficiency of corrosion is one hundred per cent. For cast iron the value of $\frac{C}{D}$ is about 1,280 and the equation becomes

$$L = 1{,}280 \cdot \frac{P}{S}.$$

Assuming 5,600 ohms per centimeter cube as the specific resistance of the soil and a drop of potential of 0.4 volts across the joint and determining from the curves in Fig. 8 the current maximum intensity reduced to this voltage we get as the maximum rate of penetration of the corrosion in inches per year:

Bell and spigot joint	0.034 inches per year
½″ wood joint	0.009 inches per year
5″ wood joint	0.004 inches per year

The time required for the corrosion to penetrate clear through a pipe ½-inch thick containing these joints is therefore as follows:

Bell and spigot	14.7 years
½″ wood	53.4 years
5″ wood	121 years

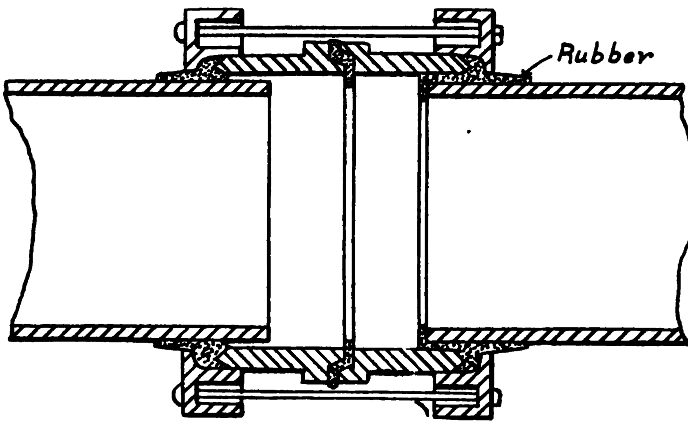
The permissible drop across a joint in ½-inch cast iron pipe for a life of 40 years is as follows

Bell and spigot joint	0.147 volts
½″ wood	0.53 volts
5″ wood	1.22 volts

In considering these figures it is well to remember that the corrosion here indicated is that due to electrolysis and is in addition to the corrosion occurring due to the soil or water. It should be added that we have found specific resistances as low as 1,100 ohms per cm. cube and under such conditions the rate of corrosion may be five times that computed above. Further, the effect of surface resistance due to paints, etc. and the effects of polarization under low voltages are not here considered so that considerable variations from the calculated values may be expected. These calculations are

of value only in that they indicate that a drop of potential across a joint can hardly be considered safe if it exceeds a few tenths of a volt, and that much can be gained by the use of a long leakage path where voltages are expected to be high. This problem is an important one and much additional work remains to be done in this direction.

It is well to call attention at this point to some of the various types of insulating joints that are now in use. These may be divided into four classes, viz.: (1) Clamped joints using a rubber gasket or other insulating material to make

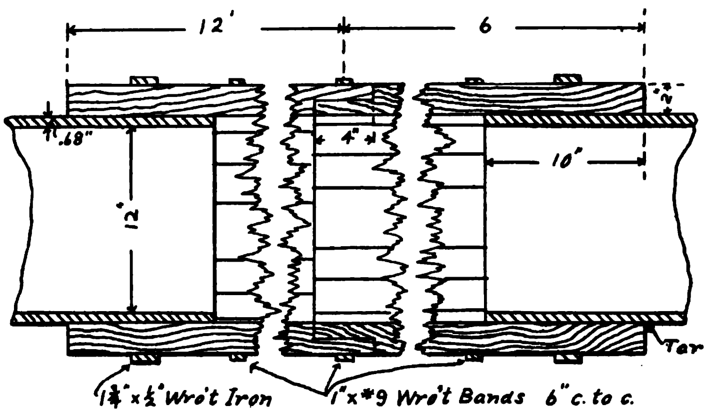


THE DRESSER COUPLING

Fig. 9.

a tight joint and provide the insulating section; (2) wooden joints, including wood stave pipe sections; (3) cement joints, of which there are various types; and (4) leadite joints. The first of these, exemplified by the well known Dresser and Hammon couplings is quite extensively used for the purpose of securing gas tight joints, and some types of these are designed also to give insulating joints. When properly designed and installed, it gives a very high resistance joint, and has been very effectively used in a number of instances for the

purpose of reducing the flow of current in the pipes. The construction of one form of Dresser coupling, known as the divided center ring insulating coupling, is shown in Fig. 9. Both of these types make very satisfactory insulating joints for most purposes, although they may, under certain circumstances, be liable to injury because of the relatively short leakage path, the importance of which has already been discussed. Under most circumstances, where the local potential



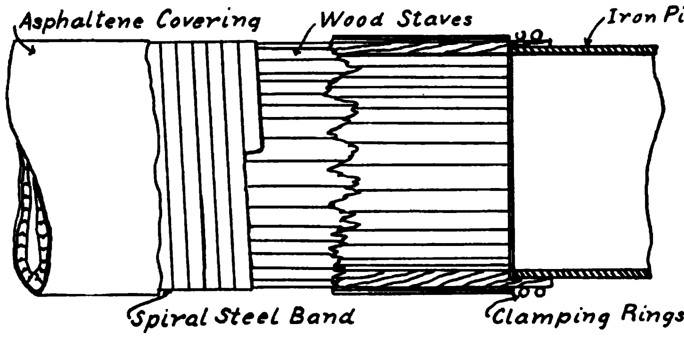
WOOD STAVE JOINT
used by the
Pennsylvania Water Company
Fig. 10

gradients are not too high this should cause no trouble. Some trouble has been reported where these couplings have been used on artificial gas mains owing to the deleterious effect of the gas on the rubber gaskets. They do not appear to be affected by natural gas, however, and in such mains they appear to show a satisfactory life.

Of the wooden joints numerous modifications are in use. One type used by the Pennsylvania Water Co. is shown in Fig. 10 which is self explanatory. This joint has a high electrical resistance, and is particularly adapted for use in places

where only one or at most a few joints are installed and the drop of potential across the joint is likely to be high. The great length of the joint is very effective in causing any leakage current around the joint to distribute itself over a considerable length of adjoining pipe, as pointed out above, and thus prevents concentration of electrolysis at the edge of the joint.

Another type of wood stave joint is shown in Fig. 11. The spiral steel band used in this construction would have the effect of materially shortening the leakage path, and while it would have ample resistance to serve as an insulating



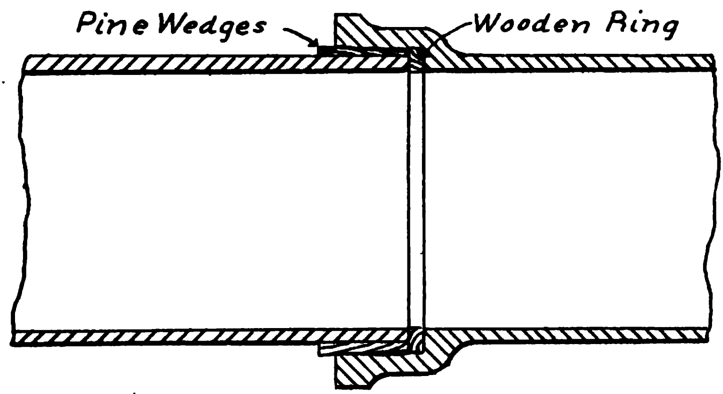
Construction of Wyckoff Stave Pipe
Showing Connection to Iron Pipe.

Fig 11

joint under most circumstances, it could not safely withstand as high a drop of potential across the joint as the one described above.

The Metropolitan Water Board of Boston uses a type of wooden joint shown in Fig. 12. This joint is simple in construction, consisting of a one-half inch wooden liner made of overlapping section of wood, the ring thus formed being wound with canvas impregnated with paraffin. The purpose of this is to prevent possible metallic contact between the ends of the pipes. The wooden staves are of clear white pine, planed to fit the curvature of the pipe, and are driven in by a special driver to prevent splintering. Any leaks that

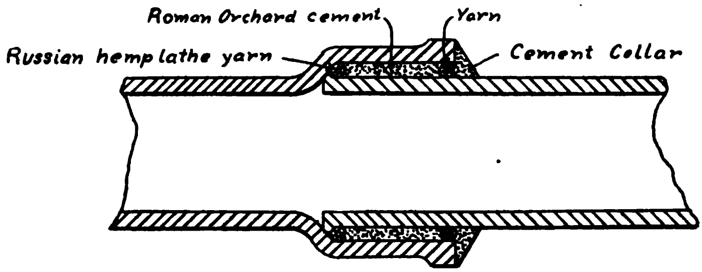
may develop are stopped with white pine wedges. These joints have been found to be very satisfactory up to about 75 lbs. pressure. Higher pressures sometimes cause moderate leakage through the pores of the wood, and this has been overcome by dipping the inner ends of the staves in red lead. In some cases the staves are reinforced by an iron band clamped around the spigot end of the pipe. Usually a slight change is made in the castings where this joint is to be in-



Insulating Joint
used by the
Metropolitan Water Board, Boston.
Fig. 12.

serted, the spigot end being cast without bead and the inside of the bell smooth without groove. The cost of these joints has been given as ranging from five to twelve dollars when installed in new lines, but when installed in old mains the cost would be much higher. The resistance of this joint is ample under all circumstances that may arise, but the relatively short leakage path would often make it necessary to use the joint with greater frequency than would be necessary with joints having a long leakage path.

Cement joints have been given a variety of forms, and one which has been used successfully for years by the Cambridge Gas Light Company, is shown in Fig. 13. In making this joint the inner ring of hemp is chosen exactly the right size to fill the annular space between bell and spigot, and this is rolled in when the pipes are set together and driven hard with the calking tool. As usually made by the Cambridge Company, no special attempt is made to keep the metal of the two adjacent lengths of pipe apart, but notwithstanding this fact the resistance of the joints has on the whole been high



CEMENT JOINT
used by the
Cambridge Gas Light Company
Fig. 13.

enough to prevent the accumulation of any considerable amounts of stray currents, and as a consequence this system has never been troubled by electrolysis, although the pipes of the Cambridge Water Company have suffered severely. After thoroughly tamping the ring of hemp into the place the cement is carefully worked into the joint with trowel and calking tool until the space between bell and spigot is filled flush with the face of the bell. Another turn of hemp the same as the first is then laid against the cement and driven in with the calking tool just under the edge of the bell. The cement is in this way rendered very dense, and on this feature

depends in large measure the success of the joint. A collar of cement is finally laid over the outer ring of hemp to protect it from rot. If success is to be achieved with this joint great care must be exercised in the making of the joints. Perfect cleanliness of the inside of the bell and outside of the spigot is necessary, and all loose scale and sand should be removed before the cement is put in place. Only the best quality of cement should be used and this should be thoroughly mixed and tamped into the joint with the greatest care. Careful bedding of the pipes is equally important as the cement joint is much less yielding than lead, and if any considerable lateral movement of the pipes takes place it is liable to break the pipe, the strength of a well made joint being as a rule greater than that of the pipe itself. In some instances, instead of making every joint of cement, every third or fourth joint only is made of cement, the others being lead. Except in extreme cases this seems likely to prove practically as effective in minimizing electrolysis troubles, and it has the great advantage that the lead joints impart a flexibility to the system that will greatly reduce troubles due to lateral motion of the pipes.

The use of leadite joints has been confined chiefly to water mains, and for such service many prefer it to any other type of joint. This material is melted and run into the joint after the manner of a poured lead joint. It is cheaper than lead and many claim that it makes a better joint mechanically. It often happens that when the joints are first made a large proportion of them will show considerable leakage, but in the presence of water they seem to have a tendency to seal themselves up and the leaks will usually cease entirely within a day or two. It is very important to see that a dense mass completely fills the joint, and it is lack of care in this respect that is probably responsible for most of the trouble with leaky joints. The runner used in pouring the joint should be so designed that there will be a head of eight in. to ten in. above the joint. If the material is at proper temperature this head is usually sufficient to insure a dense homogeneous mass of

leadite in the joint. As already noted the resistance of leadite is very high when first run, but after lying in the ground for some time its resistance decreases greatly. As to whether this will continue to such an extent as to render it worthless as a resistance joint can not be stated at the present time, but the material appears to possess interesting possibilities and should be carefully studied.

In attempting to reduce the damage from electrolysis it must be borne in mind that best results are not to be derived from the application of any one method of mitigation alone. Whatever system may be applied to the pipes, it is of prime importance to give proper attention to the condition of the tracks and negative return system generally, since the difficulties encountered in connection with any system of protection will be reduced in proportion as the drop of potential in the rail return is lowered. Since, however, as the conductivity of the negative return is increased, and the drop of potential in the negative return is brought to a relatively low value, further reductions can be accomplished only at relative great expense and after a certain point is reached it will be more economical to apply further protective measures to the pipes themselves. It is of first importance therefore to have sincere coöperation between the pipe companies and railway companies if the most effective measures are to be applied at the minimum cost to all parties.

Conclusions in regard to matters pertaining to electrolysis mitigation must be drawn with great caution, and much additional work must be done before very definite judgments can be formed in regard to many of the problems referred to above, but a careful review of the situation as regards the methods of protecting pipes by insulation, seems to warrant the following conclusions:

1. The insulating paints thus far tested deteriorate much more rapidly when subjected to electric stress than when the electric stress is absent and such paints should not be depended upon to protect pipes against electrolysis un-

less they have been thoroughly tested under conditions which subject them to electric stress.

2. Insulating paints, because of their tendency to fail locally and thus concentrate the discharge of current may do actual harm and should therefore not be used in those regions where the pipes may be expected to become strongly positive to the earth.
3. In all places where the pipes are likely to remain negative or neutral to earth, no harm can result from local failure in reducing current flow in pipes and in preventing soil corrosion.
4. Where insulating joints are properly used the pipes do not as a rule have a very strong tendency to discharge current into the earth and in such cases paints may be safely used to prevent soil corrosion.
5. The rapid deterioration of paints under electric stress is due to the fact that a trace of moisture finds its way through the coating thus permitting a feeble current to flow resulting at first in very slight electrolysis. The formation of gases and, other products of the electrolysis then causes rupture of the coating and the formation of blisters.
6. Laying of pipes in conduit or embedding them in cement is not to be recommended as a protection against electrolysis, it being a useless expense.
7. Insulating joints, when rightly used can be made very effective in minimizing electrolysis.
8. Those who have had most experience with insulating joints to date regard them as economical and entirely practical from a mechanical standpoint.
9. Insulating joints should be carefully made to insure permanent insulation.
10. Insulating joints should not be confined to positive areas but should be installed in all places where there is any considerable potential gradients parallel to the pipes and should be installed with sufficient frequency

to prevent any considerable currents from flowing in the pipes and so that a dangerous potential difference cannot occur across the joint.

11. The effective resistance of a joint depends not alone on the resistance of the joint proper, but also on the resistance of the leakage path in parallel with the joint. For this reason the effective resistance of a joint increases very slowly with increase of length so that short joints are practically as effective in reducing flow in pipes as very long joints.
12. Long joints give a much more uniform distribution of leakage current and hence less rapid deterioration of the adjoining pipes than do short joints so that in special cases where it is necessary to have a high drop of potential across the joints, a long joint is to be preferred.
13. If pipe lines containing insulating joints are connected to mains not so insulated the insulating joint immediately adjoining the uninsulated line will as a rule be subjected to higher differences of potential than elsewhere. This is particularly true if negative feeders are connected to the uninsulated main. For this reason the use of insulating joints and negative feeders on the same pipe system is not to be recommended.
14. Where insulated and uninsulated systems occupy the same territory and where it is necessary to have metallic contact between them, as inside of buildings, an insulating joint placed between the point of contact of the two systems and the point where the insulated system enters the earth will be of great value in preventing current from flowing from the uninsulated into the insulated system.

In presenting the foregoing preliminary report on certain phases of our work to date we recognize that there still remains a vast field in which investigational work must be continued for an indefinite period before we can hope to advance

our knowledge of this complex and troublesome problem to the point which the great economic importance of the subject demands. In continuing our work relating to this and other phases of the electrolysis problem it is important that we keep as closely as possible in touch with the gas, water and electric railway interests, in order that our work may be carried forward along most effective and practical lines. Any cummunications from engineers dealing with any phase of the electrolysis problem will therefore be welcomed and appreciated.

In conclusion we wish especially to express our obligation for valuable coöperation to the following named persons:

Mr. W. C. Hawley, General Superintendent, Pennsylvania Water Co., Wilkinsburg, Pa.

Mr. J. G. Pew, Vice President and General Manager, Peoples Gas Co., Pittsburgh, Pa.

Mr. C. Sholl, Superintendent, Apollo Water Co., Apollo, Pa.

Mr. Geo. C. Gensheimer, Secretary and Treasurer, Erie Water Department, Erie, Pa.

Mr. J. B. Crawford, General Manager, Pennsylvania Gas Co., Oil City, Pa.

Mr. Raymond Cross, General Superintendent, Pennsylvania Gas Co., Oil City, Pa.

Mr. A. M. Blinn, Local Manager, Pennsylvania Gas Co., Erie, Pa.

Mr. F. W. Stone, Superintendent, Ashtabula Gas Co., Ashtabula, Ohio.

THE CHAIRMAN: Gentlemen, you have heard this very interesting paper, which should bring out discussion.

A MEMBER: In connection with that five-inch wide insulating joint, what would be the effect of placing a piece of iron say of an inch section parallel to the pole, and about two inches from it on the distribution of that curve.

MR. MCCOLLUM: To make sure that I get your point, you mean if you have a joint coming up here (indicating) and breaking inside here. The joint is in here of course. Now, do you want the pipe outside of that? The effect of that would be to gradually concentrate the density of discharge on the pipe and the iron there (indicating).

A MEMBER: Put a piece of pipe and iron outside.

Mr. McCollum: You mean run it down that way.

A Member: Yes.

Mr. McCollum: That would increase somewhat the density of discharge there, not very greatly, however, depending somewhat on the thickness of the pipe. But if it was comparatively thin pipe, as the ordinary pipe would be, it would not very greatly increase the density of discharge there (indicating). Perhaps it would reduce it somewhat right here, providing this section were thick enough so that the distance between the earth and the corresponding point over there (indicating) were materially different between the pipe underneath and that point over there; but I would not expect a very great shifting of the distribution. It might be valuable at times to put on a sleeve and connect it electrically with the pipe underneath, in which case practically all of the current then would leave this metallic connection to the sleeve outside and then flow over either way of the sleeves and not the pipe itself. There would be some effect, I think, of making this distribution somewhat more uniform, if you had that in the form of a sleeve running clear around the pipe. I think it would not be of very great difference, however.

Mr. W. H. Fulweiler: I would like you to give me the linear distribution.

Mr. McCollum: How far it extends from the pipe?

Mr. Fulweiler: Yes.

Mr. McCollum: In the case of a bell and spigot joint, which I referred to here, I tried to draw that as accurately as I could. In the sketch it is shown with this pipe here is four inches in diameter. At this point the maximum is right in here, this is where the centimeter density is very high, extending up in some way, and falls down just about like that (indicating), and at a distance of four or five inches from the joint has become very low so that it is within an inch or so that the greatest current density occurs, a very few inches back, and it practically disappears. This is so low, however, that it does not cause any particular

harm. Now, with the five inch horizontal wood joint, it comes up just about like this (indicating), ultimately reaching practically the same level, the maximum being considerable less, but not sloping off as rapidly; and in the case of the five-inch joint, it comes up as the curves show just about here, to not more than a third as high as the other, and then comes off down there somewhat like that (indicating), all along the joint the lower this maximum comes, and the farther out it extends. If you go back a distance, clear up to the bottom of the pipe, or a little more, the density becomes quite low.

MR. F. N. MORTON: I should like to ask if anyone is making insulated joints and has taken the precaution to prevent connection by simply letting an iron clutch take care of it.

MR. McCOLLUM: That is a very important matter, in connection with laying the joint practically. In all our experimental results, we have used some sort of shield, say a hard cardboard shield, where the iron comes together, to insure that there is no metallic contact. We have been very careful about that. In testing systems in practice, however, where steel joints were resorted to, we have found a great many instances of metallic contact has occurred in joints that are supposed to be insulated, and it simply emphasized the fact that in practice, in using insulated joints, we should take great care that there is no metallic contact between the joints, between the sections of the pipe.

MR. CARL GRAF: The points that appeal to me most are those that trend towards prevention. Before the traction companies came into the field we did not hear much about electrolysis. Now we hear about electrolysis in gas pipes, water pipes and in the conduits of telegraph, telephone, and electric light companies, and we are now getting into buildings. It seems to me that what we are interested in, gentlemen, is prevention, and I take it, from what Mr. Stratton has said, that there are ways of preventing those stray currents. It seems to me that it should be a matter for the

trolley company, if possible, to bring back that current to where it belongs without using our property, and that it would be very much cheaper for them to do it than what it would cost all these different corporations to insulate their pipes or conduits. I would like to know what Mr. Stratton's bureau is doing in the line of prevention?

Mr. McCollum: As I said in the beginning of our paper, we are endeavoring to make as comprehensive an investigation as possible in regard to all the different possibilities in connection with this matter of electrolysis, and we are looking into the various methods that may be used to minimize electrolysis, and this is a preliminary report on one of the methods.

Now, in bringing this before the Gas Institute I do not presume to convey the idea that I think that the gas people or the water people ought necessarily to incur the expense of putting in a system of protection of this kind. It is presented merely as one of the possible methods of keeping the current off the pipes. I see no reason why an arrangement might not be entered into by which the railway companies would defray the expense of installing such a system, provided they could be shown that it will be effective when installed. To my mind the thing for us to do is to find out which of the methods are cheapest and most effective, regardless of whither they lead us and when the most desirable, cheapest, and most effective system is decided on, if anything is decided on, then it becomes a question of who should bear the expense of carrying it out. It seems to me logical that if the railway companies could be shown that the insulating joint system is better than others, they might prefer installing it, for the good of the water companies rather than be compelled to go to a more expensive or less effective system.

We are not prepared to make any final or dogmatic statements at present with regard to the relative cost of different

systems but we are studying this problem and expect to have something to say about it in the future, but for the present we have shown, and I think the paper bears me out, that the insulating joint method can be used effectively in keeping down electrolysis, at least to a minimum; and whether or not the pipe companies or the railway companies will install this, is a question that I am not prepared to deal with at the present time.

Mr. von Mauer: Mr. Chairman, I do not like to see a statement that we can cure this by insulating joints go uncombated. This is trespassing on my paper a little bit, but there is a manifold and an insulating joint and it is pretty badly eaten, the one that is pretty badly eaten is the one with the insulating joint, and as though to disprove some of our theories, it is eaten up on both sides of the insulating joints, and the manifold leads into a lamp post. It is a physical proposition. You see the current had ample opportunity to go wherever it wanted to without going through these pipes at all, but it seemed to eat them up. I am rather skeptical as to adopting any conclusion that is obtained from laboratory practice. I appreciate the work, I appreciate the importance of laboratory practice, but the American Gas Institute has the best laboratory in the world. It has plants all over the United States; it has operators all over the world, and if there is any experimenting to be done, let the energetic new officers lay down the lines, and let it be done on practical lines. As a matter of fact, the trouble with electrolysis is not usually largely in the cast-iron as against lead joints or cement joints. I am anticipating a little what I have to say later, but you have complications there that the laboratory will never find. You have your water system, and your heater pipe leads to that system, and the current goes through. What is it going to do when it gets to the main. You have changing conditions. In this particular case I put it in to see what effect the power-houses have upon it. It put in a whole street

three or four blocks long, for experiment, and after a year they moved the power-house and everything was changed.

MR. McCOLLUM: I would like to ask Mr. von Maur if he has ever measured the potential drop of those joints that were so badly eaten up?

MR. VON MAUR: They were not measured. You are speaking in your experiments of having 15 volts, and that would be a voltage that is not ordinarily found in gas systems. The damage that is done, is done I believe with voltages.

MR. McCOLLUM: While we used fifteen volts, that was not on one joint. Fifteen volts on one joint would probably destroy it within a few weeks. We have fifteen volts on the experimental pipe system but that is about 200 feet long. In this distance we have some 25 or 30 joints in series, so that the voltage across each joint was only about four-tenths to seven-tenths volt. I feel confident in asserting, as a result not only of our laboratory experiments but of observations in the field in instances where joints have been in service for years, that a drop of potential of a few tenths of a volt across a properly designed joint will not, under ordinary conditions, destroy the joint in anything less than 20 or 30 years.

MR. VON MAUR: You mean cast-iron pipe or steel pipe?

MR. McCOLLUM: I was thinking especially of cast-iron pipe. Of course steel pipe is thinner, and for that reason it would go out more quickly.

MR. McCOLLUM: I know it is a little risky to bring steel and cast-iron or different kinds of iron in contact with each other in the soil. One or the other is likely to suffer damage due to galvanic action.

MR. VON MAUR: The one without insulated cover was not so badly eaten.

MR. McCOLLUM: It is probable that there was too high a drop of potential across the insulating joints. Unless you knew that the potential was small—less than half a volt, I

don't think the criticism is a valid one. I admit that if you put the joints far enough apart, that you may have a high voltage drop across the joint and trouble will result. It is just such instances as that that has brought insulating the joint method into disrepute in some cases.

Another point has been brought out by Mr. von Maur which I wish to emphasize very much indeed, and that is the desirability of carrying out experiments on a thoroughly practical basis. We have been trying to do that just as much as we can. We have had a number of engineers working out in the field, collecting data of actual conditions. We are trying to keep just as close to practical conditions as possible.

I quite agree with Mr. von Maur that the Gas Institute has the best laboratory in the world for investigation of this kind and I would like to ask of the Institute that they coöperate with us in carrying out these investigations. There is nothing that would contribute more to the value of these experiments, than the coöperation of the various engineering bodies. It is the purpose of the Bureau of Standards in this work, as in practically all other lines of engineering research which it is carrying out, to keep as closely as possible in touch with organizations of practical men, and I hope that some arrangement may be made by which not only the Gas Institute but the Water Works Societies and Railway Companies may be brought into coöperation with us in connection with this work. A good many are already coöperating with us individually but I would like to see them coöperate as national organizations.

MR. A. S. MILLER: I should like to ask whether these experiments were made under any different conditions of acidity or alkalinity of soil, or whether they were all made in one soil?

MR. MCCOLLUM: Those from which most of our conclusions given here were drawn were made under natural

conditions of the soil. I can say, however, that we have carried out special experiments in regard to the effect of acidity of soil and alkalinity of soil, etc., and in a general way the result shows that in acid soils corrosion will take place more rapidly than in strongly alkaline soil. The effect of chemical composition of soils on the amount of corrosion that will occur under given conditions forms a subject of great importance and also one of great complexity. Much work remains to be done along this line.

Mr. Hewitt, of Toronto: The importance of this matter as it strikes me, and its value to the gas industry is the fact that the Bureau of Standards is itself taking the initiative in securing information in respect of the effects of electrolysis and the investigation will doubtless terminate in the long run in legislation which will fix the responsibility, if there be any, upon the trolley companies. From our experience we believe that the trolley companies would be only too glad to settle the damage that has already been done by the trolley system, if it could be proven against them; but having settled that damage, and adopted whatever means the gas company may have agreed upon for them to adopt to eliminate the trouble, it would be up to the gas company if the remedies applied should prove non-effective. Legislation eventually is the only thing that will fix the responsibility, and that legislation will never be obtained until the results of the investigation and experiments of the Bureau of Standards have been arrived at, and in that respect, I think we are very fortunate indeed to have given to us so much of the information that has been obtained through the experiments of the Department of Standards at Washington; and with the further information that I have no doubt will go to the department from the various gas companies on this matter, we shall get good results I am sure.

The Chairman: Any other gentleman wish to discuss this subject? If not, I think a motion will be in order, Mr. von Maur.

Mr. von Maur: I would like to make that motion, that a vote of thanks be tendered to Mr. McCollum. I also emphasize the fact that my remarks about the relation of the Gas Institute to it were to bring out exactly what Mr. McCollum has brought out.

The Chairman: You have heard the motion, that Mr. S. W. Stratton represented by Mr. Burton McCollum be thanked for his very interesting discussion of the subject. All those in favor say aye.

Motion carried unanimously.

The Chairman: The next paper is a paper by Mr. J. D. von Maur, on the "Actual Leakage in Unaccounted for Gas."

Mr. Hall: Mr. Chairman, would I be out of order now to refer to the subject of coöperation with the Bureau of Standards?

The Chairman: If Mr. von Maur will permit?

Mr. Hall: I would suggest that some definite action should be taken by the Institute, to show our coöperation. I think we ought to go further than simply to ask the bureau to send a representative here to report to us without making some effort to coöperate. I think we should be definitely on record as desiring to coöperate.

The Chairman: I think it will be proper to make a motion to refer this matter to the Board of Directors.

Mr. Hall: I would so move.

The Chairman: Gentlemen, you have heard Mr. Hall's motion, that the work of the Bureau of Standards in regard to electrolysis be called to the attention of the Board of Directors, with the suggestion that they do what they can to coöperate with the bureau in its work.

The Chairman then put the motion to the house, and it was carried unanimously.

ACTUAL LEAKAGE IN UNACCOUNTED-FOR GAS.

"Little uncollected bills,
Little leaks of gas,
Little slow or D. R. meters.
Thus the profits pass."

Judging from the latest reports of the U. S. Geological Survey, there will be manufactured in the United States during the year 1911 more than 180,000,000,000 cu. ft. of gas, and of this amount approximately six per cent., or 10,800,-000,000 cu. ft. will have been lost by actual leakage, or in other ways unaccounted for.

Just how much this loss amounts to in dollars and cents depends entirely on the items which go to make up the total of unaccounted-for-gas. These items are roughly divided into three general classes:

1. Actual loss, due to actual leakage of gas.

2. Losses due to slow or D. R. meters, or to temperature conditions under which the gas is measured, etc.

3. Unaccounted-for-gas, due to methods of accounting.

From a financial point of view the losses due to Class 2 are by far the most important, as gas which has been manufactured, distributed and actually sold represents a loss equal to the selling price of the gas. For instance, if John Smith uses 5,000 cu. ft. of gas at $1.00 per M., his bill should be Five Dollars ($5.00), but if his meter only registers 4,000 cu. ft. he will actually pay Four Dollars ($4.00), a loss to the Gas Company of One Dollar ($1.00), or the full selling price of 1,000 cu. ft. of gas.

Losses due to actual leakage of gas, Class 1, on the other hand, are equal only to the cost put into the gas up to the point of leakage, but owing to the potential danger of leaking gas, it

is of the utmost importance that leakage from this source should be kept to a minimum.

The unaccounted-for gas, due to methods of accounting, Class 3, includes such items as corrections for gas at the works, differences due to the time of reading meters, etc. It is well to note in passing that the increased sales for the last half of December of each year will always appear as unaccounted-for gas in cases where the fiscal year corresponds with the calendar year. It would be better in considering the unaccounted-for gas to have the record made for the year ending with the end of the month having the least consumption.

It is safe to say that the money value of the unaccounted-for gas in the United States is between $6,000,000 and $8,000,000 annually, an amount equal to interest on a capital of $100,000,000. How much of this loss is due to actual loss of gas to the Company, and how much of it can be saved by improved methods is more important than the question as to how the unaccounted-for gas can be reduced by different methods of computing it, but if the item "Unaccounted-for-gas" is to be used for comparative purposes, as for instance to determine the relative conditions of various distribution systems, then the methods adopted for ascertaining its value should certainly all be on a similar basis. Unfortunately this is not the case, so that it is very difficult to obtain a correct idea as to the efficiency of the operation of one Company as compared with another, from any published data. The report of the United States Geological Survey shows that the percentage of unaccounted-for-gas is by no means uniform. In 1907 it varied from 1.6 per cent. in Pennsylvania to 22.7 per cent. in Nevada, New Mexico and Utah, and in 1908 the variation was from 1.9 per cent. in Pennsylvania to 18.4 per cent. in Virginia and West Virginia, but the average for the two years remained the same, namely 5.9 per cent. Reports also show that the percentage of unaccounted-for gas varies very considerably in each state for different years.

METHODS OF REPORTING UNACCOUNTED-FOR GAS: Published reports from foreign cities seem to indicate a more uniform

method of accounting, and consequently more uniform results. Below is given the results obtained in various cities in Europe:

PERCENTAGE OF UNACCOUNTED-FOR GAS IN VARIOUS CITIES OF GREAT BRITAIN.

Cities	Percentage unaccounted-for
Birmingham	5.2
Bradford	4.8
Brentford	5.7
Bristol	7.0
Commercial	6.3
Derby	6.2
Dublin	8.6
Edinburgh	5.9
London	5.3
Glasgow	8.7
Halifax	8.5
Bolton	5.3
Croydon	5.9
Dumfries	8.5

PERCENTAGE OF UNACCOUNTED-FOR GAS IN VARIOUS CITIES OF GERMANY.

Cities	Percentage unaccounted-for
Berlin	3.2
Hamburg	2.8
Dessau	6.0
Copenhagen	5.3
Dresden	4.3
Charlottenburg	4.1
Cologne	3.1
Leipzig	3.3
Breslau	3.6
Stockholm	3.7
Leipzig	5.6

Cities	Percentage unaccounted-for
Zurich	4.3
Bremen	4.0
Dusseldorf	5.9
Stuttgart	1.2
Nurnberg	3.3
Konigsberg i. Pr.	4.7
Elberfeld	6.9
Basel	2.5
Strafsburg-Kehl	10.6
Magdeburg	7.4
Chemnitz	2.2
Rixdorf	3.1
Barmen	6.3
Karlsruhe	5.9
Essen	13.0
Kiel	5.7
Mannheim	5.6
Stettin	3.7
Wiesbaden	4.7
Crefeld	8.1
Danzig	4.0
Genf	5.1
Posen	5.9
Plauen i. V.	2.8
Cassel	5.6
Halle a. S.	4.9
Mainz	7.6
Mullhausen i. E.	7.0
Pforzheim	3.4
Duisburg	10.0
Lubeck	4.8
Lodz	3.8
Darmstadt	1.9
Saarbrucken	6.0
Braunschweig	3.9
Magdeburg	8.6

I understand that French Engineers consider that a leakage of 1 cu. meter of gas per meter run is the practical minimum that can be expected in good practice, and that one-third of the total is due to leaking joints. This is at the rate of approximately 85,230 cu. ft. per mile of main. Whether this figure is based on a straight mile basis or on a basis of leakage per mile of 3″ main, I have been unable to learn.

The method of reducing the leakage and unaccounted-for gas to a basis of so many thousand cu. ft. per mile of equivalent 3″ main is very objectionable, and for different reasons the reporting of this item as a certain per cent. of the send-out is very misleading.

Dr. Alexander C. Humphrey in a paper read before the Institute last year showed clearly how "The Public (is) Deceived by Misleading Analysis of Data," and this paper might well be extended to show how gas men are misled in dealing with reports covering unaccounted-for gas data. As a matter of fact it is impossible to represent the condition of a distribution system by either of the above methods. One management may increase profits by increasing sales, while the property is allowed to run down, whereas another management may neglect the sales and still make a fair showing by careful and economical oversight of operation, but good management should combine the advantages of careful operation with those of an energetic commercial policy.

Assume, for illustration, a company having the very simplest form of distribution system, made up of one mile of 6″ cast iron main, and one consumer located at the far end of the main. Furthermore, assume that the gas has been correctly measured at the works, and also at the consumer's meter, and that the actual leakage in the main from holder to consumer is 50,000 cu. ft. per annum, and that the total output is 500,000 cu. ft. per annum. The actual leakage under the above conditions would then be 10 per cent. of the output. Under the same conditions, assume that the output is doubled to 1,000,000 cu. ft. per annum. The distribution system is exactly the same, and the leakage in the main system is ex-

actly the same, but the unaccounted-for gas is now only 5 per cent. The management would therefore be credited with having reduced the leakage to one-half, and it might be assumed that the distribution system had been put in very much better condition than it previously was, but as a matter of fact the conditions are precisely the same.

If we assume another company operating under precisely the same conditions, with precisely the same amount of actual leakage, but having a 3″ main instead of a 6″, as in the previous case, and then reporting the amount of unaccounted-for gas as leakage per mile of equivalent 3″ main, the leakage of the first company would be reported as 25,000 cu. ft. per mile of equivalent 3″ main, and of the latter company as 50,000 cu. ft. and again the deduction might be made that the system of the first company was in 50 per cent. better condition than the company having the 3″ main, and that it had only one-half the leakage, but as a matter of fact it is more discreditable to have a leakage of 50,000 cu. ft. on a mile of 6″ main than on a mile of 3″ main, and it would be more advisable to spend money in order to reduce leakage in the former case than in the latter.

I wish particularly to emphasize the fact that in dealing with actual leakage from mains and services there is no connection between the amount of gas sold and the actual leakage. If the mains and services are simply filled with gas under ordinary distribution pressures, the actual leakage will be the same whether no gas is sold, or whether the consumption is 100,000,000 cu. ft. per year. We can therefore gain no very intelligent idea as to the condition of the distribution system by reporting the unaccounted-for gas either on a percentage basis, or as unaccounted-for gas per mile of equivalent 3″ main.

The theory back of the practice of reporting leakage on a 3″ mile basis is based on the supposition that the actual leakage will be in proportion to the circumference of the joints. No allowance is made for increased leakage due to the high

pressures used in the reinforcing mains, nor is any consideration given to the leakage from service pipes, etc.

Our experience in St. Louis seems to demonstrate that the greater part of actual leakage does not originate in the joints at all. Leakage is made up of a multitude of very small defects. A leak of 1/40 of a cu. ft. per hr., known as a pinhole leak, cannot ordinarily be detected by the sense of smell, and is very likely to be overlooked in testing out joints. If the gas from such a leak could be lighted it would represent a flame one quarter the size of the pilot light of an ordinary 71,306 mantle lamp. The following table No. 1, is given to show the magnitude of the amount of gas that would escape annually at the various rates of leakage per hour shown, and also the amount of gas that would escape from one mile of main per year, if there was a leak at each joint of from 1/40 of a cu. ft. per hr. and upward.

TABLE NO. 1.

Rate of leakage per joint, per cu. ft. per hr.	Equivalent cu. ft. per yr. per joint	Cu. ft. per year per mi. of main
1/40	219	96,360
1/20	438	192,720
1/10	876	385,440
1/5	1,752	770,880
1/2	4,380	1,927,200
1	8,760	3,854,400
2	17,520	
3	26,280	
4	35,040	
5	43,800	
6	52,560	
7	61,320	
8	70,080	
9	78,840	
10	87,600	
20	175,200	
30	262,800	
40	350,400	
50	438,000	

TABLE NO. 2A.

Leak. per cu. ft. per mi. per hr.	Leak. per mi. per year	Leak. per hr. 800 miles	Leak. per day 800 miles	Leak. per month of 30 da. 800 mi.	Leak. per yr. per 800 mi.	Cost at 50c. per M. per mi. per year	Loss per mi. capitalized at 6%	Loss per 1,000 lineal ft. capitalized at 6%
1	8,760	800	19,200	576,000	7,008,000	$ 4.38	$ 73.00	13.82
2	17,520	1,600	38,400	1,152,000	14,016,000	8.76	146.00	27.64
3	26,280	2,400	57,600	1,728,000	21,024,000	13.14	219.00	41.46
4	35,040	3,200	76,800	2,304,000	28,032,000	17.52	292.00	55.28
5	43,800	4,000	96,000	2,880,000	35,040,000	21.90	365.00	69.13
6	52,560	4,800	115,200	3,456,000	42,048,000	26.28	438.00	82.92
7	61,320	5,600	134,400	4,032,000	49,056,000	30.66	511.00	96.74
8	70,080	6,400	153,600	4,608,000	56,064,000	35.04	584.00	110.56
9	78,840	7,200	172,800	5,184,000	63,072,000	39.43	657.00	124.38
10	87,600	8,000	192,000	5,760,000	70,080,000	43.80	730.00	138.20
20	175,200	16,000	384,000	11,520,000	140,160,000	87.60	1,460.00	276.40
30	262,800	24,000	576,000	17,280,000	210,240,000	131.40	2,190.00	414.60
40	350,400	32,000	760,800	23,040,000	280,320,000	175.20	2,920.00	552.80
50	438,000	40,000	960,000	28,800,000	350,400,000	219.00	3,650.00	691.30
60	525,600	48,000	1,152,000	34,560,000	420,480,000	262.80	4,380.00	829.20
70	613,200	56,000	1,344,000	40,320,000	490,560,000	306.60	5,110.00	967.40
80	700,800	64,000	1,536,000	46,080,000	560,640,000	350.40	5,840.00	1,105.60
90	788,400	72,000	1,728,000	51,840,000	630,720,000	394.20	6,570.00	1,243.80
100	876,000	80,000	1,920,000	57,600,000	700,800,000	438.00	7,300.00	1,382.00

Table 2A. shows total leakage for one mile and for a system of 800 miles at various rates of leakage, also the corresponding financial loss and the amount of money per mile that could be expended to just equal the loss due to escaping gas.

NOTE: As an illustration, assume a leakage of 10 cu. ft. per hr., then the cost of lost gas at 50 cents per M would equal $43.80 per year. If by spending $730.00 this mile of main could be put in a condition so as to save the entire amount of lost gas for all future time, the financial net result would equal the loss due to leaking gas.

The cost of 50 cents per M. is assumed for comparative purposes only and a separate table would have to be prepared in each case on a basis of actual cost for each separate company.

The following Table, No. 2, taken from the American Gas Light Journal, is also interesting as indicating the amount of gas which will pass through small orifices, such as rivet holes in holders, under various pressure conditions.

TABLE NO. 2.

LEAKAGE IN CUBIC FEET PER YEAR.

Pressure in inches water	1/16"	1/8"	1/4"
2"	58,040	232,228	929,129
4"	82,120	328,480	1,314,000
6"	100,560	402,320	1,609,200
9"	123,200	492,800	1,970,800
12"	142,400	569,600	2,376,800
16"	264,240	656,800	2,628,000
25"	205,200	821,200	3,284,000
Pressure in inches water	1/2"	1"	2"
2"	3,716,520	14,866,200	59,464,800
4"	5,256,000	21,024,000	84,096,000
6"	6,437,200	25,748,000	102,996,000
9"	7,884,000	31,536,000	126,144,000
12"	9,116,000	36,456,000	145,828,000
16"	10,512,000	42,048,000	168,192,000
25"	13,140,000	52,560,000	210,240,000

Actual Leakage:

Having made all possible correction as to temperature, moisture, pressure, etc., at the Works, and taking due account of the condensation, etc., taken from the drips, the unaccounted-for gas will then be made up of the following items:

CLASS A.

1. Leaks at lead joints.
2. Leaks at cement joints.
3. Broken mains.
4. Split pipe or bells.
5. Loss of gas at time of making main connection.
6. Leaks due to electrolysis.
7. Leaks through walls of pipe.

CLASS B. (LEAKS AT SERVICE PIPES).

1. Services rusted through corrosion.
2. Services eaten out by electrolysis.
3. Broken or split fittings.
4. Leaks at stop-cock.
5. Gas escaping at time of making service connection.
6. Service broken.
7. Split pipe.
8. Services pulled out of main.
9. Leaks at meter or meter connections.

CLASS C. (LEAKS AT STREET LAMPS.)

1. Too early lighting.
2. Too late extinguishing.
3. Excessive consumption of burners over requirements.
4. Broken lamp posts, causing services to leak.
5. Leaks caused by similar conditions to Class B.
6. Leakage of pilot lights.

CLASS D.

1. False connections by-passing meters.
2. Slow meters.
3. D. R. meters.
4. Losses due to temperature effects.

When gas is compressed after having been measured at the Station meter and then allowed to expand through street regulating stations, etc., there will be an additional loss due to water and hydrocarbon vapors being condensed out of the gas during compression. This liquid is pumped from the high-pressure mains, and so is lost to measurement, except such portion as has already been allowed for in the original correction for temperature and moisture.

Bottle-Tight Mains:

Your Chairman of the Technical Committee has asked me to discuss particularly the question of "Bottle-tight mains." It is not a particularly difficult matter to install a system of practically bottle-tight mains; the trouble arises in keeping them so. Before we go too far into the question however, it will be profitable to examine our standard system and ascertain just how nearly bottle-tight it is or can be made, and what improvements or changes could be made, either in methods or materials, in order to reach a higher degree of perfection. By the standard system of main is meant ordinary cast iron bell and spigot pipes, laid with either lead or cement joints, and for illustrative purposes the system in St. Louis may be taken as a fair example.

During the past few years a very accurate report was kept of every leak which had been reported in this City, but it must be understood that this does not take into consideration leaks that have been found due to electrolysis or corrosion, etc., while actually rehabilitating an entire street as, for instance, ahead of paving work, but refers to reported leaks only. It so happens that the greater portion of the soil in St. Louis is a yellow clay, which in its undisturbed condition is very nearly gas tight. We have, therefore, found in our overhauling work many cases of services, etc., eaten out by corrosion or electrolysis, which in less favorable soils would have manifested themselves long before they were actually discovered.

Prior to the year 1903, the distribution system was in a

very bad condition and necessitated a vast amount of overhauling and new work. A distinction has therefore been made in the following tables showing the total amount of leaks of each class for the entire period of thirty months prior to January 1, 1911.

1st. On work done prior to January 1, 1903—called "Old work."

2d. On work done subsequent to January 1, 1903—called "New Work."

TABLE 3.

BROKEN MAINS—New Work.

(1) 3 inch broken at service.
(1) 3 inch broken by contractor.
(1) 3 inch broken (cause unknown).
(2) 4 inch bells broken.
(6) 4 inch mains broken (cause unknown).
(3) 4 inch mains broken by sewer.
(11) 4 inch mains broken at service.
(1) 6 inch main broken by sewer.
(1) 6 inch main broken at service.
(2) 6 inch mains broken (cause unknown).
No 8 inch mains broken.
No 16 inch mains broken.
No 20 inch mains broken.
No 24 inch mains broken.
No 30 inch mains broken.

TABLE NO. 4.

BROKEN MAINS—Old Work.

(28) 3 inch mains broken (cause unknown).
(5) 3 inch mains broken at service.
(1) 3 inch split sleeve broken.
(27) 4 inch mains broken (cause unknown).
(8) 4 inch mains broken at service.
(1) 4 inch broken sleeve.
(1) 4 inch broken bell.
(1) 6 inch broken bell.

TABLE NO. 4.—(*Continued.*)

(1) 6 inch main broken by graders.
(8) 6 inch mains broken (cause unknown).
(1) 6 inch main broken by sewer.
(1) 8 inch main broken on account of electrolysis.
(1) 8 inch main broken (cause unknown).
(4) 10 inch mains broken (cause unknown).
(1) 10 inch broken bell.
No 12 inch mains broken.
No 16 inch mains broken.
No 20 inch mains broken.
No 24 inch mains broken.
No 30 inch mains broken.

TABLE NO. 5.

LEAKING JOINTS—New Work.

(1) 3 inch cement joint.
(2) 3 inch lead joints.
(5) 4 inch cement joints.
(13) 4 inch lead joints.
(1) 6 inch cement joint.
(11) 6 inch lead joints.
No 8 inch cement joints.
No 10 inch cement joints.
No 10 inch lead joints.
(1) 12 inch cement joint.
(11) 12 inch lead joints.
(21) 16 inch cement joints—high-pressure.
(77) 16 inch lead joints—high pressure.
No 20 inch high pressure cement joints.
No 20 inch high-pressure lead joints.
No 20 inch low-pressure cement joints.
No 20 inch low-pressure lead joints.
No 24 inch low-pressure lead joints.
(87) 24 inch high-pressure cement joints.
(6) 24 inch high-pressure lead joints.
No 30 inch cement or lead joints.

TABLE NO. 6.—LEAKING JOINTS—Old Work.

(1) 3 inch cement joint.
(6) 3 inch lead joints.
No 4 inch cement joints.
(7) 4 inch lead joints.
No 6 inch cement joints.
(2) 6 inch lead joints.
No 8 inch cement joints.
(26) 8 inch lead joints.
No 10 inch cement joints.
(130) 10 inch lead joints.
No 12 inch cement joints.
(10) 12 inch lead joints.
No 16 inch cement joints.
No 16 inch lead joints.
No 20 inch cement joints.
No 20 inch lead joints.
No 30 inch cement joints.
No. 30 inch lead joints.

TABLE NO. 7.—SERVICE LEAKS—New Work.

(90) Services broken by graders.
(1) Service broken by Water Dept.
(4) Services broken by sewer.
(14) Services broken at main.
(1) Service pulled out at main.
(1) Leaking drip riser.
(61) Leaking at stop-cock (caused by wagons driving over stop boxes).
(2) Leaking at service header.
(2) Leaking in coal chutes.
(9) Services leaking at lamp burners.
(118) Services eaten out by electrolysis and corrosion.
(6) Services leaking at fittings.
(3) Services leaking at sand holes in fittings.
(4) Service pipes split.
(146) Service broken, caused by lamp posts being struck by vehicles.

Table No. 8.
Service Leaks—Old Work.

(45) Broken by grader.
None broken by Water Dept.
(3) Broken by sewer.
(4) Broken at main.
(2) Broken (cause unknown).
(25) Services leaking at cock.
(250) Services eaten out by electrolysis and corrosion.
(38) Defective fittings.
(3) Leaking in coal chutes.
(2) Leaking at service headers.
(1) Leaking at sand hole in fitting.
(2) Leaks at valve stems.
(81) Services broken (caused by lamp posts being struck by vehicles).

Table No. 9.
Total Mileage of Mains. (Approximate.)

	Size	1903	1911
Under	3″	12	7.54
	3″	100	73.60
	4″	211	394.23
	6″	91	210.74
	8″	25	24.83
	10″	24	33.92
	12″	21	58.52
	16″	10	20.53
	20″	8	12.17
	24″	4	26.36
	30″	.3	1.14
	Total	506.3	863.58

Referring to Table No. 9 it will be noticed that the amount of new work is about equal to 70 per cent. of the amount of the old work, or approximately 41 per cent. of the total.

In addition to this a large portion of the old work has been rehabilitated during the past eight years. About 80 per cent. of all the mains installed were laid with cement joints, and of late years practically all of the joints have been made with cement.

Discussion of Tables Nos. 3 to 8 inclusive:

Referring to Table 3 it will be noticed that there is very little danger from broken mains 6 inches and over in diameter, when properly laid.

Referring to Table 4, it is evident that the trouble from broken mains is almost entirely confined to the sizes 4 inches and under. As a matter of fact, in the years 1903 and 1904 we had as many as thirty 3 inch broken mains in the single month of January.

The deduction to be drawn, therefore, from Tables 3 and 4 is that if a main system is made up of cast iron bell and spigot joints from 6 inches to 30 inches in diameter there is practically very little danger of leakage from broken mains and consequent leakage of gas due to this source.

Referring to Tables 5 and 6, it is very apparent that low-pressure mains of all sizes from 4 inches upward can be laid with practically no risk of excessive leakage, if the mains are properly laid and the joints properly made with cement. Even with lead joints the leakage is not as great as is ordinarily supposed.

Sometimes a general condition will cause an entire line to leak at the joints. This is illustrated in Table 6, where (130) 10 inch lead joints were found leaking. This main was laid many years ago, and was found to have from 24 inches to 30 inches of cover, and located directly under a rail of a street car track.

The lesson to be learned is that great care should be exercised in selecting the proper location for gas mains. If there are street car tracks on the street there should be a main on each side of the street as near to the curb as possible.

When we come to medium high-pressure mains, that is,

those operated at 3 to 5 pounds pressure, we find some trouble with leaking joints.

In the case of the 16 inch joints in Table 5, will say that this high-pressure main was laid under very bad soil conditions, alongside of a street car track, and parallel to a large water main, and never showed any leaks for two years. A sewer was then constructed through the solid rock to a depth of from 10 to 20 feet, alongside of this 16 inch high-pressure main. It is only fair, therefore, to consider the leaks on this line to be caused by exceptional circumstances. The main laid on that part of the street on which no sewers have been constructed has remained absolutely tight.

In the case of the 24 inch high-pressure mains, shown in Table 5, would say that all of these leaks were found on mains after being laid about six months. Not a single leak developed on tests for the entire distance of 4 miles. The main was tested from 10 to 50 pounds, the higher pressure being used occasionally in order to ascertain just how well the work was being done. Every pipe was laid on counter-sunk blocks, so that the cause of the leaks was either due to contraction or expansion, or else to an inferior grade of cement for this purpose. From comparison with other work done we feel satisfied that the trouble in this case was due to the latter cause.

The deductions to be drawn from Tables 5 and 6 are that it is possible to make iron pipe low-pressure system practically bottle-tight, as far as the joints are concerned, provided the joints are made with cement and no size less than 6 inches utilized.

If there is any considerable amount of high-pressure mains laid with diameters above 16 inches, then there is still some doubt as to the possibility of making these mains absolutely bottle-tight. Certainly they can be made as tight as where the joints are made with lead, and possibly more so. "Should the writer be called upon in the future to lay any large size high-pressure cast iron mains he will probably recommend

that the joints be made with cement, in the usual manner, and while the cement is still damp apply a leak clamp to the joint as an additional precaution. We have repaired leaking cement joints on the large mains by cutting out about two inches of the cement and then recaulking the joint with lead. Thus far we have found this to be satisfactory, but cannot say that it would be satisfactory if applied to an entire line of main, although it presents possibilities." The extra expense is warranted as it costs from $10.00 to $15.00 per joint to repair a 24 inch leaking high-pressure joint where the main is laid under an expensive pavement.

In order to bear out some of the above statements I am quoting from Mr. Walton Forstall's discussion of Mr. Simpson's paper before the American Gas Institute last year.

"The practice of using cement instead of lead for small pipe was begun in 1900, and, in 1902, extended to all sizes. From the beginning a careful record was kept of all leaks found in cement joints, because it was thought important to know exactly what success or failure, was met with. The results to the end of 1909 are as follows:

Size of pipe (inches)	Feet laid	Leaky joints
4	105124	7
6	1333953	25
8	49891	3
12	59967	19
16	33687	54
20	51833	99
30	20521	332

From the above table it can be seen how nearly bottle-tight a main system can be made where cement is utilized, and the work properly done. The table also illustrates how much more difficult it is to make the larger size joints gas-tight.

Lead Wool:

The writer had intended to add some data on joints made with lead wool, but it was thought best to leave this matter

to be brought out in the discussion. Certain it is that lead wool joints on low-pressure mains can be made tight, although at a very much increased expense over other materials. As to high-pressure joints on large sized mains, the writer has not been able to gather any data.

Before leaving the subject of joints, it will be interesting to consider for a moment the practice of "Barring for Leaks." This practice will only show the existence of leaks of considerable magnitude. If the soil is one that does not very readily allow gas to pass through it, then the bar-hole will not disclose the presence of very small leaks. On the other hand, if the soil is of a gravelly nature, or one that will conduct the gas away freely, the results will be even more misleading. The practice has its advantages, but it is not safe to assume that a main is tight, simply because barring over the joints has not disclosed leaks.

In general, then, we must look for the greater actual leakage beyond the cast iron system.

Referring to Tables 7 and 8, we can see at once, from the very much larger number of leaks, both in old and new work, and also the larger number of causes which can contribute to a service leak, that the bulk of the leakage lies in the service pipe system. From both tables we note the large number of services broken by contractors grading streets about to be paved. A large portion of this could have been avoided had the mains been laid to proper depths, and the lesson to be learned is that gas companies should insist on not laying mains, except where the street is graded, so that the mains can be laid to proper grade. If there is some urgent reason for doing otherwise, then a correct profile should first be obtained, in order to avoid future expense. Both tables show a large number of leaks at the stop-cocks. Practically all of these leaks are due to the fact that the streets on which the leaks developed were uncurbed, so that the wagons passing over the stop box crush down the service box on the service, causing the leak. The stop cocks used in St.

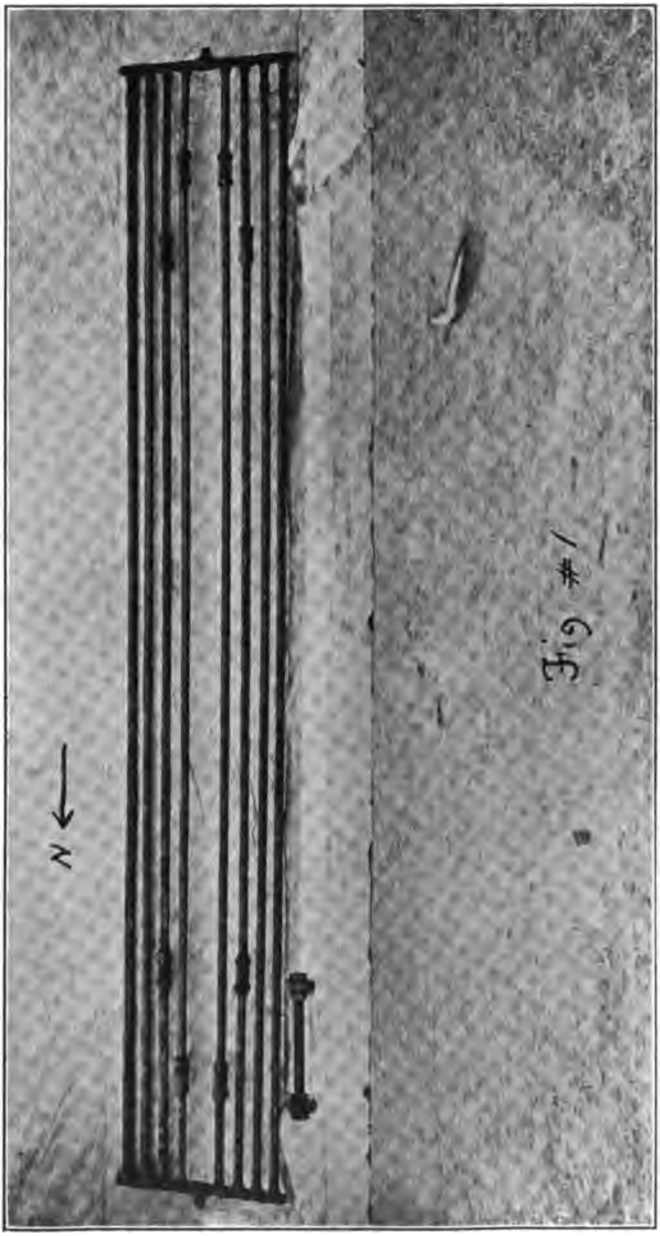
Louis are made with a cast iron body, with brass plug and washer, and although they have been in use for a number of years, we have on record practically no cases where a leak has occurred in one of these cocks in ordinary service. It is very difficult to prevent this class of leaks on unpaved streets, but it is suggested that around the stop box small pieces of flag stone be placed so as to relieve the stop box of as much strain as possible.

Services will always be broken by contractors working on the street, and there is no remedy except that of vigilance.

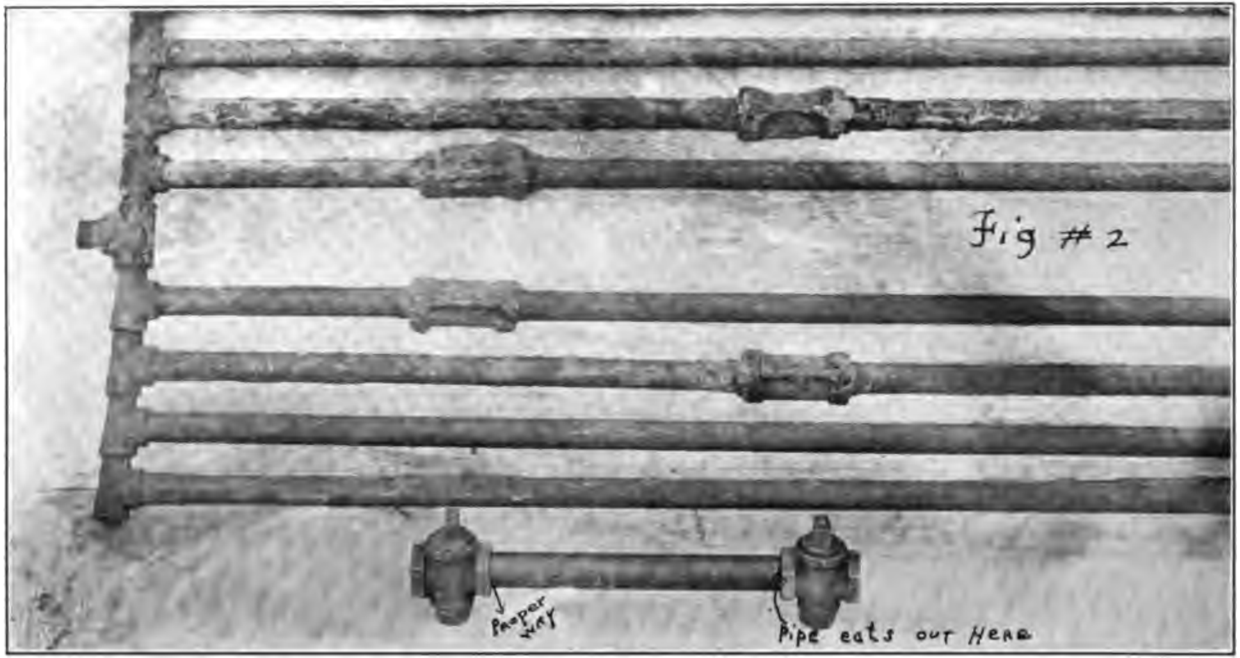
Defective fittings and pipe form a large portion of the leaks in both tables. A careful inspection will reduce this number to a minimum.

Broken and leaking services, caused by lamp posts being broken by passing vehicles, stand out prominently in both tables. There is no way of preventing this, and it is our system to collect damages from the responsible parties, wherever the responsibility can be fixed.

The item of "rusted out" or "corroded" services has always been a very large one, and in the opinion of the writer this can never be entirely prevented, but the damage can be much lessened by properly coating the pipe. "In St. Louis the practice is to coat all service pipe laid on streets where we have reason to suspect excessive corrosion, and this practice will probably be extended to all service pipes laid in the future, provided experience shows that the covering adopted, or some other to be developed, proves to be satisfactory." The coating is known as "Nicholls' coating," (named after one of our Superintendents) and is made up by covering the pipe with alternate layers of hot pitch, or other suitable compound, and paper wound spirally on the pipe. Up to a certain limit the effectiveness of the coating can be increased by increasing the number of coats of paper and pitch, but for ordinary purposes four coats will be found to give very satisfactory results against ordinary corrosion. The cost of this coating is


N
Fig #1

This half nearest to tracks.



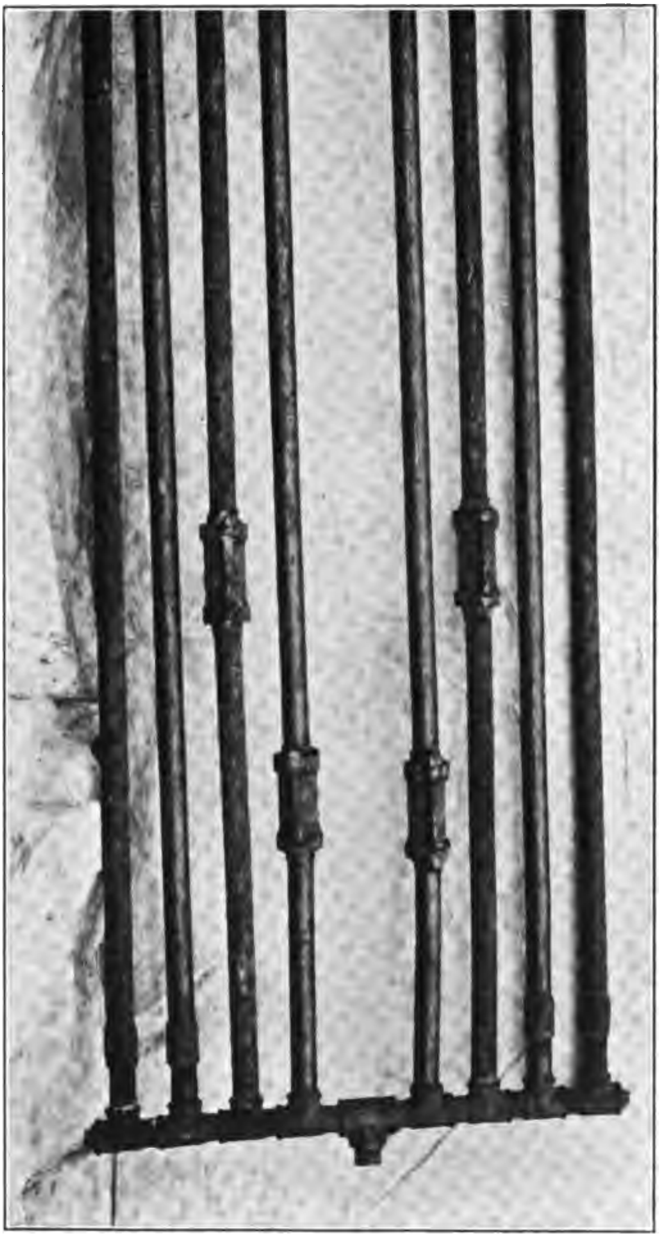


Fig. 3. This half farthest from tracks.

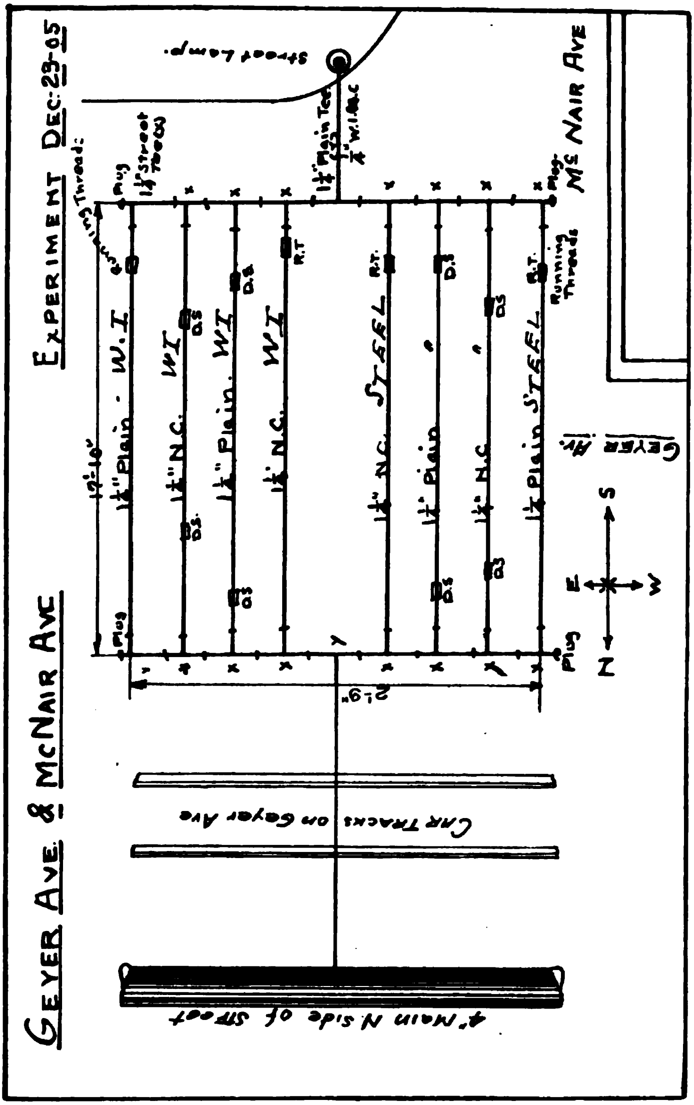

Geyer Ave & McNair Ave
Experiment Dec. 23-05
Street Lamp.
McNair Ave
Geyer Av.
Car Tracks on Geyer Ave
4" Main N. side of Street
17'-10"
2'-9"
1¼" Plain W.I
1¼" N.C. W.I
1¼" Plain W.I
1¼" N.C. W.I
1¼" N.C. Steel
1¼" Plain
1¼" N.C.
1¼" Plain Steel
Running Threads
Plug
D.S.
R.T.
S
N
E
W

Fig. 4.

about 1.1 cents per foot. In order to demonstrate the value of this covering a manifold of pipe was made up, as shown in Figs. 1, 2 and 3.

The pipe leading from the main to the manifold is covered pipe and passed under two street car tracks. As shown in the sketch, Fig. 4, the manifold is made up as follows:

One 12-foot length of uncoated pipe. W. I.
One 12-foot length of coated pipe. W. I.
One 12-foot length of uncoated pipe. Steel.
One 12-foot length of coated pipe. Steel.
One 12-foot length of uncoated pipe, with Dresser coupling. W. I.
One 12-foot length of coated pipe, with Dresser coupling. W. I.
One 12-foot length of uncoated pipe, with Dresser coupling. Steel.
One 12-foot length of coated pipe, with Dresser coupling. Steel.

This manifold was installed, as shown, in December, 1905, and was removed in March, 1911, and was therefore in the ground for a period of five years and three months.

Fig. 1 shows the manifold complete, the left of the figure corresponding to the North. The sketch, Fig. 4, shows the relative position of main, manifold and street car tracks.

Fig. 2 shows the North half of the manifold, and therefore the part nearest the tracks.

Fig. 3 shows the South half of the manifold, and therefore the part farthest from the tracks. The pipe leading from the gas main to the manifold, and therefore passing directly under the street car tracks, was also covered with the paper covering, and is still in practically perfect condition.

One half of each pipe has been cleaned and the covering removed, whereas the other one-half has not been disturbed. The manifold is now on exhibition for inspection by those members who wish to examine it. It will be noted that in every case the coated pipe is in practically perfect condition.

The street on which this experiment was made was one on which a power house of the Street Railway Company was located, and one on which the damage from electrolysis was probably the greatest in the city, but about one year after the manifold was installed the power house was abandoned and the electrolytic conditions entirely changed. This manifold will be referred to again under the head of "Wrought vs. Steel Pipe," but for the present it is sufficient to note that the paper-covered pipe has given excellent results. It might be noted that this same coating was tested by Mr. Harper of Chicago, together with some other ninety coatings of various kinds, and came through all of the tests with practically a perfect record. The result of these tests has already been published in the Gas Journals of October, 1909. It is also interesting to note that the pipe on which the insulated couplings were placed suffered by far more than any of the others, although in the case of the covered pipe with insulated couplings the pipe is still in perfect condition.

Next, taking up the question of leakage caused by split pipe, split bells, split service fittings, services pulled out of mains, leaks at meter connections, etc., it will probably be impossible to entirely prevent leaks from these causes, but if the pipe and fittings used are of sufficient strength, and are properly inspected and installed, the trouble from this cause can be largely eliminated, and this can only be attained by willingness on the part of the company to pay the bill. In large cities 50 to 60 per cent. of the time of inspection and supervision is wasted in traveling between jobs. The remedy is to be found in providing the most modern means for the men to get over the ground. Some companies are waking up to the need of furnishing those in active general charge of the work with the means to accomplish the best results, but much is still to be desired. The benefit to be derived lies in the future, whereas the pay of the men, and the cost and maintenance of equipment is in the present. This is the stumbling block that has done more to hold back intelligent pro-

gress in distribution work than any other factor I know of. The Inspector or General Foreman is only of value while actually on the job, and is of practically no use while traveling between jobs.

Electrolysis:

One of the most prolific causes of actual leakage is that due to electrolysis. Much has been written on the subject and many theories have been advanced, but after one has read and listened to them all he is as much in the dark as ever as to just what practical steps he should take to prevent damage which is constantly going on in the particular system over which he has charge.

The writer, while having no theories to advance, feels that if the following rules are intelligently followed, the leakage from mains and services due to corrosion and electrolysis, as well as from other causes, will be materially lessened, although the final solution for the prevention of electrolysis must be found by finding a way by which the Railway Company must utilize its own property for the the return of its currents to the power house instead of that furnished by the pipes of the conduit companies. Possibly we will yet see the day when street cars will be moved under a system which will not require the use of wires or rails to carry the current, the energy being supplied by some form of high efficiency storage batteries, but in the meantime we have to suffer and pay the bills. The respective managements of the conduit and railway companies should get together. The damage cannot be corrected by simply reading or writing papers, but much can be done by the responsible heads of the various companies meeting together and working under some definite plans, and utilizing the information and data furnished by those papers, etc.

One thing is certain, namely, that nothing thus far has been developed which can be installed at reasonable expense by the gas company that can prevent the tremendous damage

which is constantly taking place in the destruction of our gas mains and services.

Some General Rules for Street Work:

The following rules refer particularly to large cities, and are intended to lessen the amount of unaccounted-for gas due to actual leakage. Many of the rules are based on what has already been said in this paper:

1st. Lay no pipe smaller than 6 inches, except in special cases. This will make the bulk of the main system of 6 inch and 8 inch pipes; all mains to be used to be of cast iron, and at least as heavy as the standard used by the Philadelphia Gas Company.

2d. Use cement joints entirely for all sizes of low pressure mains up to 30 inches inclusive. There may be circumstances where this rule will have to be modified. For high-pressure mains 16 inches to 24 inches inclusive, cement will probably give at least as good results as lead, but these mains must be laid with unusual care. Leaks will probably develop within a year after the main is laid, but after these have been once repaired there will be very little future trouble. It is admitted, however, that the making of joints on large high-pressure mains is one of the most difficult problems with which we have to contend. It is advisable to use a leak clamp on each joint as an additional safeguard.

3d. Use full weight wrought iron or steel pipe, and a comparatively heavy beaded fitting for all service work, coating the pipe with at least four coverings of pitch and paper, as described, or some equally effective covering. The pipes should be left free from covering for a distance of six inches from each end, as this will assist in preventing the workmen from damaging the covering while using the wrench. When the service is completed this part of the pipe should be pitched and papered, in order to make it equally as efficient as the balance of the service. It is good practice to also coat the fittings with pitch, cement or asphalt at the point where the service joins the main. The coating described is tough and

will stand hauling and fairly rough usage, but it cannot be abused, as for instance drawing it through the sharp teeth of the jaws of a vise or dragging it out of the wagon over some metallic substance, such as the head of a bolt. Should one of these services subsequently be found to be eaten out by electrolysis the service should be renewed, using the same kind of pipe, but in this instance place the pipe inside of a tile pipe, after which the space between the tile and service should be filled with pitch. The service fittings at the main should be thoroughly coated. The pitch and tile will absolutely prevent electrolysis and corrosion, although it is at a very high first cost. It should be remembered, however, that only that part of the service actually in the tile pipe will be protected. The fittings, lamp bends, etc., will still have to be specially treated.

4th. All threads should be cut so as not to leave any part of the thread exposed outside of the fitting, as shown at the bottom of Fig. 2. Experience shows that both electrolysis and corrosion attack this part of the pipe more rapidly than at any other point.

The importance of this is best shown by examining the manifold referred to in this paper. We find the services eaten out at the thread, while the balance of the pipe is in good condition.

5th. (a) Where there are street car tracks, a main should be laid near the curb on each side of the street, and in the opinion of the writer, no other single one thing will do more to avoid danger by electrolysis than this. But it must be admitted that to do this is to apply a very expensive remedy.

(b) Lay no main with less than 3 feet of cover, where the climate is similar to that of St Louis.

(c) On very wide streets, such as boulevards, lay a main on each side of the street, close to the curb.

(d) On residential streets lay either one or two mains, depending on local conditions, but where one main is used it should be laid with a cover varying from 3 ft. 6 ins. to 4

ft. 6 ins., depending on local conditions. It is a mistake to lay mains with excessive cover, for the reason that the cost of repairs is excessive, and also that leaks are likely to go on unnoticed.

(e) On streets where there are two street car tracks, and on which it is desired to lay only one main, this main should be laid as near as practicable to the curb on one side of the street, and with such a cover as will keep the services crossing under the street car tracks a reasonable distance away from the tracks. Good judgment on streets of this character is particularly essential.

6th. Lay no mains on ungraded streets unless an exact profile of the future grade of the street is available.

7th. Where there is no curbing protect all stop boxes by means of small pieces of flagging placed around the box. Do whatever is possible to prevent water from reaching the service pipe outside of a service cock.

8th. Under no circumstances lay a main or service on or through any solid structure, such as conduits, manholes, sewers, etc., and do not allow others to build these structures on or around mains or service pipes.

9th. Lay no mains on filled-in ground until same is properly settled. Lay no service pipe or main in the same trench with other conduits.

10th. Allow no electric bonding of any kind from any portion of the distribution system to street car tracks, or to other conduits.

11th. In filling in trenches use no material for filling which may have a tendency to corrode the pipe, such as cinders, etc.

12th. Stand for a little greater cost and lay every main and service as it should be laid, namely, on solid, undisturbed ground, and in the case of the larger mains use solid blocks countersunk so that top of block is flush with surface of the ground.

13th. To avoid mains breaking at the service, and services breaking at the main, see that the main is properly strength-

ened wherever the tap hole may have a tendency to weaken the pipe. Ordinarily this is done by the use of cast iron split service sleeves. These sleeves are expensive, and probably equally as good results can be obtained by using sleeves made of cement.

These sleeves cost, in place, about one-sixth what cast iron sleeves cost. The forms are made of No. 20 galvanized iron, provided with a hook joint at the top. An opening is left through which the street tee is inserted. After the service pipe has been run the space between the pipe and the sleeve is filled with cement in exactly the same manner as is used in making up standard cement joints. These sleeves of course, are used in connection with the small size mains only.

An experiment recently made by the writer, and tested under the direction of Prof. Van Ornum of the Washington University, showed an adhesive strength of a good brand of Portland cement to cast iron, not specially prepared, of 25 pounds per square inch.

14th. Finally, have every one in charge of the work fully alive to the fact that he is not building for the day only, but for many years to come. Provide a sufficient number of men to thoroughly inspect all work done, and provide these men with the necessary conveniences to enable them to see as much of the work as possible, and thus properly supervise the work.

Even when all of the above rules are rigidly followed, and additional ones equally good, and perhaps better, that may be mentioned by others more capable than the writer in dealing with this problem, we will still have some leakage, but the amount will be confined to very much smaller limits than at present.

What can be expected is best shown by some tests of actual conditions. The following tests, shown in Tables 10-11-12-13 and 14, were made by testing stretches of mains, together with the consumers' services and lamp services attached to them after first making sure that the lamp cocks and the meter

cocks along the route selected had been closed. The method employed in making the test is practically the same as that described on Page 423, "Catechism of Central Station Gas Engineering of the United States," in answer to Question 227 of the Practical Class.

In selecting mains for test a number of mains were selected at random. A second lot was selected with a view of getting the very worst conditions in the City. A third lot was selected as representing work done since 1903, and finally a number was selected by disinterested parties. It is fair to assume that the final results show a true condition of the general distribution system.

The tests were all carefully made and where there was any doubt as to the bags holding, the mains were actually cut, thus isolating the main under test. About one-half of the total were so made. All leakage was measured through a test meter. Any leakage through the consumers' meter cocks would, of course, show up as leakage.

Column 10 in the following table is calculated on the basis of considering all service pipe and all cast iron pipe 6 inches in diameter and under as 6 inch pipe, and reducing the larger sizes to equivalent 6 inch main.

Special Tests: A number of special tests were made for specific purposes:

1. Six thousand four hundred feet of 24" high-pressure main was isolated from the system and tested with mercury gauge for two hours without showing any drop in pressure.

2. Seven thousand four hundred and eighty feet of 24" high-pressure and 4,050' of 12" high-pressure line were isolated from the system for a period of four hours.

The pressure in the test line was first raised to 5 lbs. and the pressure outside of the valves in the balance of the high-pressure system was then lowered from 2¾ lbs. to 1¾ lbs. Any leakage through the valves (3 in number) would then pass from the test line to the balance of the system, but no gas could leak past the valves into the pipes being tested.

TABLE No. 10.

Test No.	Size of main	Kind of joint	Length of main	No. of services	No. of lamps	Measured leakage	Rate per mi. per year	Rate per mi. on 3″ basis	Rate per mi. on 6″ basis, inc. services	Cons. per lamp per hr.	Remarks
1	3″	Lead	969′	51	4	5.000	238,710	238,710	64,200	3 cu. ft.	Very old
2	3″		300′	—	—	0.025	3,854	3,854	......		....
3	3″	Cement	300′	5	—	0.000	0	0	......		....
4	3″	Lead	300′	4	1	0.000	0	0	......		....
5	3″	Cement	110′	4	—	6.000	2,530,000	2,530,000	893,500		Very old
6	3″	Lead	250′	6	—	1.300	240,000	240,000	109,100		
7	3″	Lead	1,550	58	—	3.000	89,400	89,400	31,230		
8	3″	Lead	385	32	—	7.500	900,000	900,000	174,500		
9	3″	Lead	383	16	—	0.000					
10	3″	Lead	387	16	—	1.200	143,500	143,500	43,000		
11	3″	Lead	380	8	—	4.000	486,000	486,000	237,000		

TABLE NO. 10.—(*Continued.*)

Test No.	Size of main	Kind of joint	Length of main	No. of services	No. of lamps	Measured leakage	Rate per mi. per year	Rate per mi. on 3" basis	Rate per mi. on 6" basis, inc. services	Cons. per lamp per hr.	Remarks
12	3"	Lead	610	30	—	20.000	1,520,000	1,520,000	438,500		
13	3"	Lead	600	0	—	0.000					
14	3"	Lead	175	0	—	0.000					
15	3"	Lead	300	15	—	3.75	578,160	578,160	161,060		
16	3"	Lead	294	3	1	0.00	0	0	0		
17	3"	Lead	840	33	5	0.00	0	0	0		
18	3"	Lead	295	15	0	0.00	0	0	0		
19	3"	Lead	430	21	2	0.00	0	0	0		
20	3"	Lead	516	22	0	0.40	35,828	35,828	11,145		
21	3"	Lead	352	12	0	0.40	52,560	52,560	19,000		
22	3"	Lead	290	8	0	0.00	000	000	000		
23	3"	Lead	420	14	0	0.90	99,113	99,113	36,357		
			10,436	373	13	53.475	237,000	237,000	81,886		

TABLE No. 11.

Test No.	Size of main	Kind of joint	Length of main	No. of services	No. of lamps	Measured leakage	Rate per mi. per year	Rate per mi. on 3″ basis	Rate per mi. on 6″ basis, inc. services	Cons. per lamp per hr.	Remarks
1	4″	Cement	220′	3	—	0.000					
2	4″	Cement	1,100′	51	6	0.500	20,550	15,411	6,128	3.1	
3	4″	Lead	920	36	5	2.300	115,500	86,900	37,800	2.6	
4	4″	Cement	1.269	45	6	0.000					
5	4″	Cement	696	23	3	0.0				3.0	
6	4″	Cement	1,429	22	10	0.0				3.0	
7	4″	Lead	408	23	1	0.0				3.0	
8	4″	Cement	1,400	20	9	0.70	23,150	17,400	12,550	3.0	
9	4″	Cement	1,550	10	8	0.30	8,950	6,715	6,265	3.0	
10	4″	Lead	1,720	76	11	0.10	2,628	1,971	782		
11	4″	Lead	400	11	3	0.00					
12	4″	Lead	512	14	2	4.00	360,500	270,100	147,800	3.0	

TABLE NO. 11.—(*Continued.*)

Test No.	Size of main	Kind of joint	Length of main	No. of services	No. of lamps	Measured leakage	Rate per mi. per year	Rate per mi. on 3" basis	Rate per mi. on 6" basis, inc. services	Cons. per lamp per hr.	Remarks
13	4"	Lead	1,144	38	4	1.13	45,600	34,250	16,780	3.0	
14	4"	Lead	1,144	39	4	0.380	15,350	11,500	5,540	3.09	
15	4"	Lead	1,110	69	6	6.400	266,000	200,000	63,100	3.05	
16	4"	Lead	385	11	2	0.500	60,000	45,000	23,700	3.1	
17	4"	Lead	234	13	—	1.600	316,000	237,500	83,800		
18	4"	Lead	500	11	7	0.0					
19	4"	Lead	784	15	4	0.0				3.0	
20	4"	Cement	609	30	4	0.0					
21	4"	Cement	1,120	51	5	0.40	16,470	12,395	4,900	3.0	
22	4"	Cement	325	8	0	0.00					
			18,979	619	100	18,310	44,570	33,500	1,634	2.98	average

TABLE NO. 12.

Test No.	Size of main	Kind of joint	Length of main	No. of services	No. of lamps	Measured leakage per hr.	Rate per mi. per year	Rate per mi. on 3" basis	Rate per mi. on 6" basis, inc. services	Remarks
1	6"	Cement	3,662	160	20	2.5	31,550	15,775	10,440	Lamp 3' per hr.
2	6"	Lead	780	30	6	2.0	118,500	59,250	38,500	Lamp 3.6' per hr.
3	6"	Lead	860	56	5	0.9	48,450	24,225	11,060	Lamp 3.2' per hr.
4	6"	Lead	950	52	5	7.0	340,000	170,000	88,750	Lamp 3.1' per hr.
5	6"	Lead	1,140	36	4	0.64	25,900	12,950	9,800	Lamp 3.18' per hr.
6	6"	Lead	1,200	23	8	0.00				3.0' per hr.
7	6"	Cement	924	0	0	0.00				
8	6"	Lead	950	41	6	5.00	243,500	121,750	74,040	Work done by contractor 1903.
9	6"	Lead	3,105	18	13	4.80	71,480	35,740	54,040	
10	6"	Lead	1,854	57	7	12.00	299,000	149,500	114,500	Old-coated water pipe relaid, 1904.
11	6"	Cement	1,650	80	9	0.00				
12	6"	Cement	1,854	73	4	1.00	24,990	12,495	8,300	Lamp=3.04' per hr.
13	6"	Lead	1,340	90	11	5.45	188,000	94,000	41,600	
14	6"	L. & C.	600	1	3	0.00				
15	6"	L. & C.	8,500	35	16	0.00				

TABLE NO. 12.—(*Continued.*)

Test No.	Size of main	Kind of joint	Length of main	No. of services	No. of lamps	Measured leakage per hr.	Rate per mi per year	Rate per mi. on 3″ basis	Rate per mi. on 6″ basis, inc. services	Remarks
16	6″	Lead	850	26	2	0.50	27,230	13,615	10,540	
17	6″	Cement	1,520	56	8	0.40	12,190	6,095	4,130	Lamps average 3.22
18	6″	Cement	500	0	0	0.0				cu. ft. per hr.
			32,239	834	127	42.19	59,860	29,930	25,450	3.15

TABLE NO. 13.

1	8″	Lead	2,500	60	14	0.00
2	8″	Lead	1,030	31	6	0.00
			3,530	91	20	0.00

TABLE NO. 14.

1	12″	Cement	700	—	5	0.00				This main lowered 2′ before testing.
2	12″	Cement	600	1	6	0.00				Laid 1904.
3	12″	Cement	3,900	27	28		0	0	0	Laid 1904.
4	12″	Cement	1,520	92	7	0.00				Lamp 3.14 cu. ft. per hr.
			6,720	120	46	0.00	0	0	0	

(NOTE:—Calculations in above table made with slide rule.)

The pressures were taken from long water tube gauges, and observation taken to nearest tenth of an inch.

Knowing the volume of the pipe line tested and the drop in absolute pressure, the leakage was calculated.

The pressure in the test line was then dropped to 34/10" water pressure and the outside pressure allowed to remain at 1¾ to 2 lbs.

The amount of gas leaking through the valves into the test line was then ascertained by calculation, as above.

The result showed a leakage of 88.9 cu. ft. per hour.

While this method is not all that could be desired, it gives an indication of the amount of leakage and was the only method that could be employed that would enable us to put the line in operation at very short notice. The results are all on the safe side, and the actual leakage is probably less than the results would indicate. The line tested consisted of 7,480 ft. of 24" pipe and 4,050' of 12" pipe, all laid with cement joints, and is equivalent to approximately 38,000 feet of 6" pipe.

The leakage would therefore be at the rate of approximately

108,160 cu ft. per mile of 6" main per year, or
54,080 cu. ft. per mile of 3" main per year.

3. A mercury pressure test for 2 hours at 5 lbs. pressure was made on a mile of 12" main laid in 1907 with cement joints. No drop of pressure could be observed in 2 hours' time.

4. But all of the above high-pressure tests are more or less unsatisfactory, and in order to get a better idea of actual conditions a number of joints were actually uncovered and bar holes were made over a great number of others. The joints were selected at random throughout the city. An attempt was made to select locations where the probability of finding leakage was greatest. The results were as follows:

24″ line a — 4 cement joints uncovered—no leak.
24″ line b — 2 cement joints uncovered—no leak.
24″ line c — 2 lead joints uncovered—1 leak.
24″ line d — 12 cement joints uncovered—1 small leak at bottom of bell.
5 lead joints uncovered—no leak.

Four of these lead joints were exposed on a bridge and were practically the only ones in a mile of main with all cement joints. They were found slightly leaking last winter, and probably will have to be recaulked once a year.

24″ line d—Bar holes made over 75 joints, detected a very slight odor in one hole where main is laid 16 feet deep.

16″ line e—Bar holes made over one mile of main. No leaks found.

16″ line f—Bar holes over 16″ high-pressure line where rock excavation was made for sewer. This is the line referred to in Table 5.

24″ line g—(same as special test No. 2)—Three cement and 1 lead joints found leaking.

5. There are still a few wide streets in St. Louis where there are two street car tracks and a main on only one side of the street. Before rehabilitating the mains and services on one of these streets a test was first made. The street is brick paved and 80 ft. wide between curbs, and the main was found 6 ft. south of the south track, having been laid before the street was widened some 12 years ago. There were 33 services from this main, the greater part of which passed under the street car tracks. The total length of small pipe was 1,800 feet.

A test was first made by actually cutting out a section of pipe on each side of the street. The test showed a leakage of 1½ cu. ft. per minute. A new main was then laid near to the curb, on the opposite side of the street, and all services to houses on that side of the street relaid, and the old ones cut off from the old main. No work was done on the old main nor on the services on the south side of the street.

The test was then repeated and showed a loss of 1 cu. ft.

per hour as compared with the previous loss of 1½ cu. ft. per minute.

All pipe encountered during this work was inspected and found to be in fair condition, but on taking out some sections from under the tracks they were to be found in very bad condition. No amount of "barring for leaks" would have discovered this condition.

6. During the year 1890 there was laid in St. Louis several mains of wrought iron pipe with converse couplings. One of these mains was 12″ in diameter and was laid from Station "B" to Station "D," a distance of 3 miles. One thousand feet of this main was tested and found to leak at the rate of 46.8 cu. ft. per hr. On examination the main was found to be rusted out in spots. Accidentally an old service pipe was found which had been abandoned but never cut off from the main and was leaking badly. After this service was cut off a second test was made of the same 1,000 ft., together with 2,500 ft. additional, and was now found to leak only 1 cu. ft. for the 3,500 ft. of 12″ pipe. I estimate we can still use this main for a period of perhaps 2 to 5 years. As the main was laid under average soil conditions and in the year 1890, it would seem that the life of a wrought iron main under these conditions is approximately 23 years.

Another main of the same kind of pipe, and laid at the same date was also tested. It is a 4″ main and the test included 34 services in a distance of 440 feet, and was found to leak 24 ft. per hr., or at the rate of 288 ft. per mile per hour, or 2,522,880 cu. ft. per year. This main was taken up and replaced with a 6″ cast iron main. Near the end of eight lengths of the wrought iron pipe holes were eaten clear through the pipe in some cases as large as 1″ in diameter. Otherwise the pipe was in fair condition, and would indicate a life for wrought iron mains under these conditions of approximately 20 years. At the same time it is also clearly shown how the life of a steel or wrought iron main is decreased where electrolysis exists.

The tests shown in Tables 10, 11, 12 and 13 cover

10,436 ft. of 3″ main.
18,979 ft. of 4″ main.
32,239 ft. of 6″ main.
3,530 ft. of 8″ main.
6,720 ft. of 12″ main.

a total of 71,904 feet of main and 2,037 services, and 306 lamp services, exclusive of high-pressure main tests. The services would measure about 107,961 feet, exclusive of street lamp risers.

Assuming now that the tests represent a fair average of the leakage of the whole distribution system, it would seem to indicate a total actual leakage from mains and services in the low-pressure system of approximately 50,000,000 cu. ft. per annum, or about 1.0 per cent. of our output.

LEAKAGE ON 30 TO 40 POUNDS HIGH-PRESSURE LINES:—

It is even more difficult to obtain any very reliable information of actual leakage on high-pressure steel or wrought iron mains operating under 30 to 40 pounds pressure.

In one system made up of 123 miles of mains and services, varying in size from ¾″ to 6″ in diameter, a test was made by noting the drop in pressure during the night hours of practically no consumption. The test indicated a leakage of approximately 30,000 to 40,000 cu. ft. per mile of pipe per year. But in speaking of leakage from high-pressure mains it is well to bear in mind the fact that while the actual leakage may be high, yet if reckoned on a basis of actual gas passed by these mains the percentage of leakage may be very low if reduced to a capacity basis of pipe delivery as compared with the capacity of low-pressure mains. But the fact must also be borne in mind that the leakage from a cast iron main will probably remain more uniformly constant from year to year, whereas the wrought iron or steel pipes will probably leak at a very much greater rate as years roll by. Some of the cast iron mains, whose tests are shown in this

paper, are over 50 years old. What will the leakage be in wrought iron and steel pipes when they reach this age?

WROUGHT IRON PIPE VERSUS STEEL PIPE: There has been much discussion relative to the merits of steel and wrought iron pipe. The principal difficulty lies in the fact that the steel manufacturers have been making changes in the manner of making steel pipe during late years, and it is exceedingly difficult to get a fair comparison between the different materials. From the personal experience of the writer the conclusion seems evident that steel pipe purchased, say 10 years ago, is inferior to wrought iron pipe which was purchased say 15 to 20 years ago. As an illustration—about a year ago we had occasion to renew a 1¼" steel service pipe which had been in the ground less than 5 years, owing to its leaking from corrosion. Before leaving the job the Foreman discovered an odor of gas, and eventually found a ¾" service at the curb which was uncapped, except where it had been filled with clay. On tracing this service back to the main he found that it was an old service pipe laid possibly 20 years ago at a distance of about 18 inches from the location of the new service. This ¾" pipe was undoubtedly wrought iron, and was in practically perfect condition, yet in this same soil the steel pipe had corroded out in less than 5 years' time; but even illustrations such as this do not tell the whole story, as there may have been some local conditions which might account for the different results obtained from the two pipes. It seems to be almost a rule that the smaller size service pipes, which in St. Louis are practically all wrought iron, are in better condition than the larger size services, and it may be that owing to the smaller size pipe it becomes more perfectly covered with the surrounding clay, which in some measure protects it, or there may have been some sort of coating on the pipe when originally laid. The natural rust covering, together with the clay which the rust seems to cement to the service, is very important, and was mentioned in the lecture given by Prof. Ganz some years ago at the Detroit Meeting.

Whatever the final decision may be with regards to the relative value of wrought iron and steel, it is pretty safe to say that while a bottle-tight main system may be constructed with the use of wrought iron or steel pipe, it will be practically impossible to make it remain so at a reasonable expense in large cities, where electrolysis exists.

From a practical standpoint the question of steel pipe versus wrought iron pipe is no longer so very important, as far as gas service conditions are concerned. It will be more profitable if attention is withdrawn for awhile from this phase of the question and an earnest effort made to find some form of covering for either wrought iron or steel pipe which will materially lengthen its life. The writer feels that this can best be done by the manufacturers, and it is to be hoped before many years have elapsed that we can buy a covered screw pipe which will have at least double the life of the bare pipe. At present city conditions are such that neither wrought iron, steel or ingot iron will withstand the conditions, and at best the difference in the life of either of them will be but a few years. What we want is a life of 30 to 40 years for our service pipes.

The sketch given below, Fig. 5, represents a second manifold of pipe made up similar to that shown in Fig. 4, for the purpose of obtaining more information relative to the merits of wrought iron versus steel pipe. The manifold was installed near the corners of Compton and Park Avenues, this city, and after remaining in the ground over four years was taken up intact and sent to Detroit to be exhibited at the meeting of the American Gas Institute. Unfortunately it reached that city too late for exhibition. The location selected was a particularly bad one, and the services were eaten out periodically.

No. 1 was a wrought iron plain pipe with two Dresser insulating joints near the header.

No. 6 was the same, using steel pipe.

No. 2 was a 1¼″ steel pipe covered with our Nicholls' paper covering.

No. 5 was a wrought iron pipe with the same covering.

No. 3 was a 1¼″ wrought iron plain pipe.
No. 4 was a 1¼″ steel pipe.

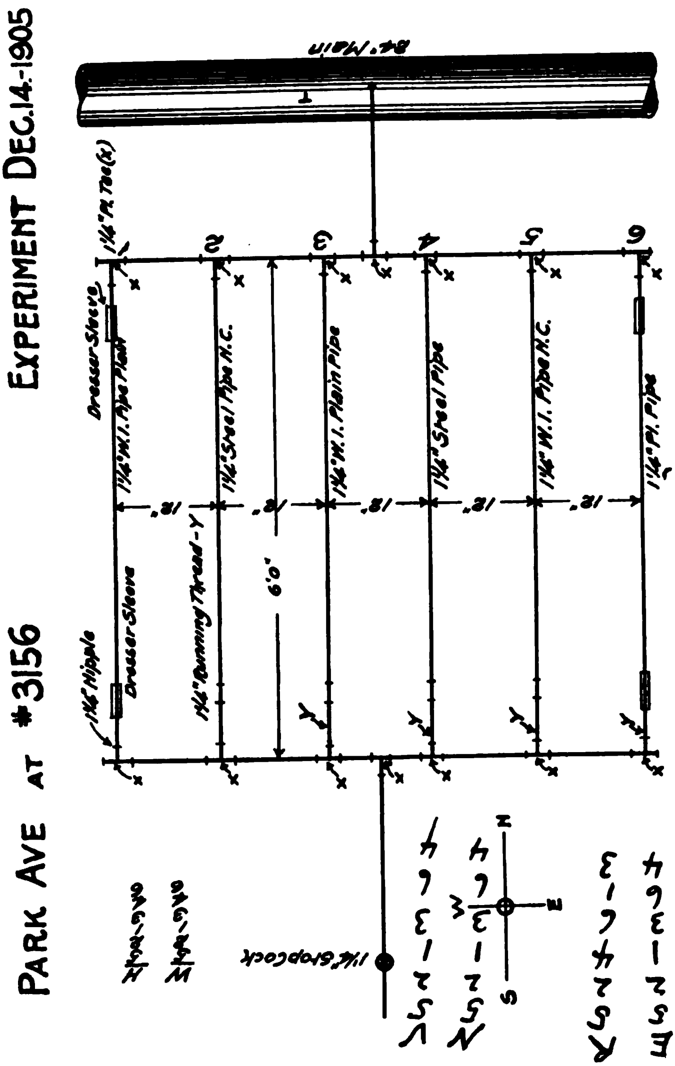


Fig. 5.

Theoretically, a current passing from service to main should divide inversely as the resistance of these separate pipes.

Pipes 2, 3, 4 and 5 should all carry equal amounts of current, practically speaking, but after four years in service the following results were found and agreed upon by some eight engineers who inspected it.

No. 5 showed up almost perfectly.

No. 2 was second best.

No. 1 was agreed upon by all as being third best.

No. 6 all agreed was in the worst condition.

No. 3 and No. 4 all agreed were worse than 5, 2 and 1, but better than No. 6.

In order of merit these pipes stood in the following order:

No. 5 was a wrought iron pipe with Nicholls' paper covering.

No. 2 was a 1¼" steel pipe with Nicholls' paper covering.

No. 1 was wrought iron plain pipe with Dresser joints.

No. 3 was a 1¼" wrought iron plain pipe.

No. 4 was a 1¼" steel pipe.

No. 6 was a steel pipe with Dresser joints, with a difference of opinion as to the relative merits of 3 and 4.

STREET LIGHTING: In this city all lamp posts are equipped with a street gas lamp controller. One thousand four hundred and eighty-seven of these governors were tested and showed an average consumption of 3.007 cu. ft. per hr. It is apparent, therefore, that whatever unaccounted-for gas is due from the street lighting system results more from early lighting and late extinguishing, and from small leaks, than from any other source. Nothing but constant supervision will avoid severe losses from this source.

If a street lamp is supposed to burn at the rate of 3 cu. ft. per hour, a slight leak at the burner, or a leak caused by the pilot light not being entirely turned off will result in a leak which, while small, will amount to an important item in the grand total. If the street lamp is supposed to burn 3 cu. ft. per hr. for 4,000 hours per year, the consumption will equal 12,000 cu. ft. per year. Now if there is a leak at the burner, say as small as 1/10 cu. ft. per hr., the total leakage in one year for the time the lamp is not supposed to burn will be

476 cu. ft., or very nearly 4 per cent. of the consumption paid for. If the leak is one that is a loss for the whole year we will have a net loss of 876 cu. ft. per year, or 7.3 per cent. of the gas paid for. This illustrates the need of careful inspection and supervision over this class of work.

A Suggestion for a Better Method of Reporting Unaccounted-for Gas: I think I have now shown that the great weakness of the standard distribution systems to-day is not in the cast iron mains, but is in the wrought iron and steel pipes, and I recommend that the American Gas Institute adopt a new rule for reporting unaccounted-for gas for purposes of comparison which shall take into consideration this fact, as well as some of the other features mentioned in this paper.

Since the object of studying the item of unaccounted-for gas is to determine the two important items of actual leakage from the distribution system, and unaccounted-for gas due to other causes, the principal of which is D. R. and slow-registering meters, it should be given in such terms as will take into consideration all of the factors entering into the problem. Every company should have on record the average per cent. of error of meters as they are returned from service. This average test will ordinarily be on the slow side, and the leakage should first be corrected by subtracting from the total unaccounted-for gas the per cent. equal to the average percentage of error of the meters as far as known.

The leakage as corrected above now more approximately represents actual leakage from the system, and this leakage, as shown in this paper, is not made up entirely from the escape of gas from the mains, but to even a greater extent from the leakage from the service pipes.

Probably the bulk of the larger distribution systems are made up of 6″ cast iron pipe, and it has been shown that this size pipe will probably remain at least as tight as any other size that might be chosen. It is suggested, therefore, that the 6″ main be chosen as a standard, and all sizes of cast iron main larger than 6″ be reduced to a 6″ basis, and all

cast iron mains less than 6″ in diameter be considered as equivalent to a 6″ main.

While the cast iron main will probably only leak gas at the joints, the opportunity for a steel or wrought iron pipe to leak is present at every point of the surface of the pipe, and it is important to note that when once the service pipe is punctured, the opportunity for gas to escape is vastly greater than a joint in a cast iron main. The weight to give the steel or wrought iron pipe would depend strictly on the outside area of the pipe, but for practical purposes it is probably sufficient to consider all steel or wrought iron pipe as so many feet of 6″ main. The leakage, as mentioned above, should then be divided by the sum of the cast iron pipe reduced to a 6″ basis, where the diameter is above 6″, plus the actual cast iron pipe below the size of 6″, plus the total length of screw pipe, regardless of its size. While this method of describing unaccounted-for gas is not entirely satisfactory, it at least has the merit of giving weight to most of the important items which go to make up the unaccounted-for gas. If we let

U = unaccounted-for gas (corrected as suggested above),
A = length of all C. I. pipe 6″ in diameter or less,
B = length of all steel or W. I. pipe,
C = all C. I. pipe over 6″ reduced to 6″ basis,
Then the leakage per mile of equivalent 6″ pipe =

$$L = \frac{U}{A + B + C}.$$

Thus far we have only considered that portion of the unaccounted-for gas known as "Actual Leakage." We now have to consider the gas lost to the company due to the incorrect registration of consumers' meters. Assuming that the gas has been properly measured and corrected at the works, and that the meter when set in service is in proper condition, the correctness of registration will very largely depend upon the conditions surrounding the location in which the meter is set. In this respect gas companies have been very lax, and the comparison of the conditions surrounding the installation of an electric meter with those surrounding the in-

stallation of a gas meter would show up very unfavorably to the latter. It is to the interest of all concerned that a gas meter should be located where it will not be subjected to mechanical injury or to extremes in temperature. As a matter of fact, we find them frequently located under some of the very worst possible conditions. Mr. Gartley, Mr. Rusby and others have shown very clearly the effect of changing temperatures on meter diaphragms. While this subject is not in the province of this paper, yet it cannot be repeated too often that gas companies should exert greater care and insist that meters be properly located.

In these days when the number of pilot lights of various kinds are being installed it is more important than ever that the meter should register on the smallest possible flame.

A 71,306 lamp burning 4 cu. ft. per hr. for 3 hrs. per day will consume 12 cu. ft., and if the pilot burns for the remaining 21 hours, the consumption will be 2.1 cu. ft., or 17 per cent. of the consumption of the lamp while burning. This illustrates the great necessity of keeping our meters in the best possible condition.

The writer cannot agree that any very large percentage of unaccounted-for gas is made up in this latitude, at least, on account of temperature conditions surrounding the meter, but the effect of the changing temperature in effecting the diaphragm certainly affects the registration of the meter, and undoubtedly a very large amount of gas reaches the consumer without being recorded on the meter dial. This subject of correct meter registration naturally brings up the question as to the advisability of making meters into "Dipping Meters," but inasmuch as this whole subject is being handled by the Committee on Consumers' Meters, it would be better to await the results of the Committee's investigation.

No mention has been made of steel pipe for mains made up, for instance, like the Monnesmann steel tubes, which I understand are extensively used abroad.

The published statements from foreign manufacturers are

very flattering, especially when the pipe is covered with Hessian cloth or jute cloth impregnated with asphalt.

Nor has any mention been made of the various types of cast iron pipe joints other than the standard bell and spigot.

The writer has confined his observations to, and has dealt only with facts brought out in actual practice, and these do not show any excessive loss of gas from cast iron bell and spigot joints when the pipes are laid under the conditions under which the writer has had experience. There may be and possibly are localities where other materials and other varieties of joints may prove effective, but at present I can see no great advantage that would result by a change to some other material, at least in our large cities.

Actual leakage can best be reduced by improving our service installation, and reducing the number of very small leaks at street lamp burners, supervising the lighting and extinguishing of the street lamps, locating meters in proper locations and using care in making service and main connections.

But the largest item in the unaccounted-for gas account is undoubtedly due to the improper registration of meters, the average tests of which are invariably on the slow side, but this paper attempts to deal only with that part of the unaccounted-for gas due to actual leakage in the distribution system, and if the discussion will bring out suggestions for better methods to reduce the amount of this item, the object of writing this paper will have been obtained.

October 11, 1911.

The manifold shown on page 322 deserves special attention. This experiment was made not only for the purpose of ascertaining the efficiency of the paper covering, but also to ascertain the relative merits of wrought iron and steel pipe when laid under exactly the same circumstances. When the manifold was taken up there was nothing to show that one material had shown less resistance to corrosion than the other, and for awhile the writer was in doubt as to whether an error had not been made and similar materials used throughout the mani-

fold, and in order not to give out misleading data all mention of the fact that half of the manifold was made of wrought iron and the other half of steel was omitted.

Fortunately Mr. F. N. Speller, of the National Tube Company, came to St. Louis, and the manifold was shown to him.

The surface of each of the pipes was filed so as to expose the surface. On two of the pipes black specks appeared, regardless as to the depth of the filing. This indicated the presence of cinder, and suggested the material as being wrought iron. The remaining pipes showed a perfectly homogeneous surface, indicating steel. The filings were then taken from each of the pipes and analyzed—the analysis showed the following results:

No.	Carb.	Mag.	Oxides	Material
Long screw	trace	0.12	about 2%	wrought iron
1	"	trace	"	" "
3	"	"	"	" "
6	0.07	0.31	trace	soft steel
8	0.07	0.31	"	" "

It is difficult to make an exact estimation of the oxides and slag in iron or steel.

The original record was then compared with these results and it was found by all three methods that the results were the same, namely, the pipes on the west of the manifold are steel, and the pipes on the east of the manifold are wrought iron.

This experiment is especially important as we have here both materials installed under precisely the same conditions, with the result that it is practically impossible to say which of the materials came through the experiment in the best condition, and it would indicate that under these conditions, at least, the difference between wrought iron and steel pipe is negligible. The writer feels free to admit that he had expected the wrought iron to outlast the steel.

I also have a photograph which is particularly valuable as it shows a case of corrosion where a wrought iron nipple, a malleable iron bushing, a wrought iron coupling and a steel nipple were connected together and excavated after being in the

Gas Line Corroded On One Side, As Shown In Photograph, After Eight (8) Years Service.

ground for eight years. All of these fittings are badly eaten, and the wrought iron appears to be in a worse condition than the steel, but all show the short life of either material, and the great need of a protective covering, at the same time it is only fair to the wrought iron to note that being nearest to the main it naturally suffered most from the electrolysis. Had the relative position of the steel and wrought iron been reversed the steel would probably have been in very much the same condition as the iron.

THE CHAIRMAN: Gentlemen, you have heard Mr. von Maur's paper. Is there any discussion?

MR. G. T. MACBETH: Among other things Mr. von Maur says or thinks that, there is nothing in the usual way of figuring unaccounted for gas on the percentage basis. He has not told us what the St. Louis "unaccounted for" is. I would like to ask what that is? Also on top of page 303, he says, "French engineers consider approximately eighty-five thousand, two hundred and thirty cubic feet per mile of main good practice." I wish I could get down leakage to that point. We have been working on ours for the last two or three years. Our figures for the year 1909 were 169,674 cubic feet per mile, 3" basis, per year. The first nine months of 1911 were 156,748 and we think we are making some progress.

On top of page 308 he says: "Having made all possible correction as to temperature, moisture, pressure, etc.," I would like to ask what system they use for correcting for moisture? I don't know whether Mr. von Maur has any wrought iron mains or not. If he has, I should think he would want to include "Leakage at screw joints" under Class A, page 308. I think he ought to add, "Actual gas taken to fill new mains laid." Perhaps he has included that in the amount lost at time of making main connection. I suppose they are using all cocks on services in St. Louis, but yet he refers in the paper somewhere to a leakage of valves. I would like to ask whether he uses some service valves or whether he used all service cocks at curbs?

The same thing applies in Class B, page 308, on the service pipe question as in Class A. The actual amount of gas taken to fill the new services laid should be listed.

There is still another class that might be added on page 308. He mentioned that he had a broken service sleeve; he has neglected to show any class for leak caused by broken service sleeves, and I would like to ask whether he has had trouble with the above sleeves? We had some trouble with pattern of a cast-iron sleeve warping, causing unnecessary strain on sleeve when they were put on main; we got about a dozen out on district before it was discovered. I think they were all found and fixed up. We haven't had any trouble since.

I would like to know in the overhauling of mains, that Mr. von Maur speaks of, how long he figures they will last and when he would undertake to overhaul them again, or whether he thinks his overhauling work would last from three to five, or ten to fifteen years? He recommends nothing less than six inch mains being laid in city streets. I agree with him, but he shows a number of leaks in his district, caused by what he calls "Broken mains, New work," including some three and four inch mains broken which were laid under "New work."

He speaks of "high pressure" in his paper. When we speak of high pressure we usually imply about 20 pounds. If we are speaking of belt line pressure we usually say either transforming or pumping main pressure. I would like to find out exactly what pressure he means, or how many pounds he refers to?

He speaks on the third line of page 311 of a six inch main broken by sewer. I don't know whether he has much rock in St. Louis or not, but I would like to ask whether he puts mains through or around sewer manholes in streets? Whether he has any trouble with service boxes located in the street wearing through on the pipe outside of the service cock due to the constant pounding on the top of the box, and the wearing of the bottom edge of the box, on the service pipe itself. I heard of some of this trouble outside of my territory,

but I believe that district is now using a box with a flanged edge where same crosses over pipe.

He speaks on page 323 of a Dresser wrought iron coupling. I don't know whether he means just a Dresser coupling designed for wrought iron pipe, or whether he means a Dresser coupling made out of cast iron or from wrought iron material. We have had some trouble not with deterioration of the service pipe itself, but with electricity getting into the cellar. I would like to ask him if the insulating of pipe with pitch would prevent this trouble as well as the corrosion?

I would like to ask Mr. von Maur whether he has tried filling out his old lead joints with lead wool after they were hammered back. It works very satisfactorily if you can drive the joint far enough back.

He speaks frequently throughout the paper about electrolysis, and I would like to ask whether any survey has been made in St. Louis, and if so, the volts and amperes he has found on his pipe.

Here is a list of the broken mains that we had in Westchester County since the first day of January, 1910, to the first day of March, 1910. We had 25 main breaks, the largest main being a six inch. The average cost of repairing all those breaks was $41.94 each. I will give list to the secretary if he so desires.

In connection with leakage work, we have done some work of this kind in the last three years. We did a very small amount in the year 1909, stopping actual leakage of 1,506,211 cubic feet with an expenditure of $1,014.78, or $3.46 per leak actually found. The money spent for this work for the year 1910 was more; the leakage stopped a little less, so the results were not as good. We spent $2,260.70 and only saved 1,319,665 cubic feet, in finding and stopping 444 leaks.

THE CHAIRMAN: Any further discussion?

MR. GRISWOLD, of Denver: I would like to ask Mr. von Maur a question. On page 300, second paragraph, he made mention of the fact that the increase of business in the last half of December was unaccounted for. I think that he should add

that the increase of business for the entire period over which we are figuring leakage will appear as unaccounted for for one-half of that period. In other words, the entire increase of business each month for one-half of that month will appear in the total unaccounted for for the year. In most companies I think that is a small item.

Mr. von Maur has pointed out to us that leakage in the service is several times as great as in the main from which these services are fed. He also calls attention to the unaccounted for appearing by reason of the inaccuracy of the consumers' meters. It strikes me that possibly a better way to report unaccounted for would be per service rather than per mile of main upon any basis, because that would cover the bulk of the actual leakage, and it would also be proportionate to the unaccounted for arising by reason of the inaccuracy of consumers' meters.

MR. WALTON FORSTALL: Mr. Chairman, there are one or two points that I would like to emphasize in Mr. von Maur's paper. I agree with him that I would like to see nothing but six inch pipes instead of three or four inch. In Philadelphia we have mostly six inch, but I have never been able to prove that it would pay to replace all our three and four inch because of their greater liability to leakage. I have prepared a table which shows for 1910 the number of breaks or leaks for different sizes of main per mile, and while, of course, the three and four inch break more in proportion than the six inch, the increased breakage would, as I have said before, never warrant a replacement of all these mains with six inch. In Philadelphia, shortly after we took control, there were many miles of streets changed from cobble to asphalt paving. Prior to this change we replaced any three inch main with six inch, and all four inch mains were so replaced that were considered badly located. In this way, we have been able to reduce our two inch mileage from 40 to 16, our three inch from 323 to 159 and our four inch from 539 to 493, while our six inch has increased from 91 to 481.

As a striking example of the difference between the three-

inch and six-inch as to leaks, in one of our districts this summer, where we have 260 miles of mains and about 60,000 meters, the only leaks we had in one month were two leaks on old services and one leak on new, and no main leaks, while in another district with a lot of three inch and two inch mains, we had in one winter month 55 broken mains. A slight difference.

We have had a good deal of trouble in Philadelphia with one or two pumping mains which we laid in 1898, at the time when we were practically working under the old Bureau of Gas conditions, and I thought it might be of interest to tell what we have done to try and stop those leaks.

After many of the joints had been recaulked twice within several years, we decided in 1905 to use leak clamps. Since then we have put on 112 thirty inch, 144 twenty-four inch, and 309 twenty inch pretty evenly divided in point of time throughout the last six years. Only one of these has been found leaking, and this was probably due to the rubber being improperly placed at the time of installation. Of course, we may have trouble at any time. It was a question with us whether or not any leaking gas could reach the rubber of the clamp in sufficient volume to give us enough deterioration to produce leakage. So far we seem to have been successful.

On page 320, Mr. von Maur shows a pipe eaten away where the threads are exposed. He solves the difficulty of exposed threads by screwing his pipe into the cock or fitting far enough to cover all the threads. Our solution in Philadelphia has been the use of what we call a recessed fitting, of which I show some samples. You will note that the recess is simply a prolongation with an enlarged diameter of the fitting. In this way, while only full threads are engaged, any male threads not engaging with the female threads are contained within the recess. We fill the space between the recess and the outside of the male thread with our coating, and in this way thoroughly protect the exposed threads. These recessed fittings cost a little more than the ordinary kind, but we decided that without them the weakest point of our service would be at our exposed threads,

and that we might have a hole eaten through much faster there, than at any other point.

Mr. von Maur speaks about the cost of coating the service pipe. In Philadelphia we have about 500,000 feet of 1¼ inch pipe to coat each year, and we find it costs us two-tenths of a cent for material, and one-tenth of a cent for cleaning, inspecting and coating, so the cost is negligible.

He speaks about the objections to laying the service through solid structure, such as conduits, sewers, manholes, etc. Where a conduit company finds it necessary to enclose our main within a manhole, they have usually been willing to pay all of the expense that we were thus put to. Usually we have laid the main around the manhole, but in some cases, where this has not been possible, we have enlarged the main in the manhole, making it at least 6 inches in size. We have received over $15,000.00 from one company for the cost of taking mains out of manholes.

Mr. von Maur says that every main should be laid on solid undisturbed ground. We don't believe that. We don't believe that in city conditions, you can get as good a foundation for mains on solid undisturbed ground as you can on blocks, and our record with our mains, with cement joints laid on blocking shows that all the mains, except possibly a little of the twenty and some of the thirty-inch have remained tight for years, so we are satisfied to stick to blocking. If we had working for us a very good farmer who had laid miles of drains for years, and who could make the nicest kind of ditch, then we might be willing to try laying on the ground, but as it is, we prefer to use blocking.

I believe that Mr. von Maur, where he does use blocking, tries to have his pipe rest on both blocking and ground. We would be afraid that we never could be sure that the pipe was resting on both the blocking and the ground, and that the danger we run of having the pipe only rest on the ground, would not warrant our adopting Mr. von Maur's practice.

We are always careful to block our services so that no strain

brought on a service can be transmitted to the main. I agree very heartily with Mr. von Maur on the question of laying mains in such a way that you don't have to cross under tracks with services. In Philadelphia our houses are so close together that it is usually most economical to lay two mains on each street on which there is a car track.

Now as to the much discussed question of wrought iron vs. steel pipe. We put underground in 1905 a number of specimens of both wrought iron and steel, coated with various materials. We uncovered them several months ago, and the steel pipe that has been coated with the Hickenlooper mixture, was apparently in better condition than the wrought iron which had been treated in the same way. In general, we find that the Hickenlooper mixture stood better than any other coating which it would be practicable for us to use, for the only coatings which were in better condition than the Hickenlooper mixture, were all coatings of so brittle a nature that they would crack from the pipe under working conditions before the service could be laid, or else require a higher temperature for their application than we consider practical under our conditions.

Mr. F. Hellen: I am very much interested in Mr. von Maur's paper, particularly so on the question of leakage of gas on a percentage basis. The great trouble with people is, as Mr. von Maur claims, they reduce the percentage of gas by increase of sales, and don't reduce the actual leakage at all. I believe the great trouble with gas unaccounted for lies with the superintendent of manufacture, who has no interest in the distribution department, and in such cases you always find that your gas unaccounted for is large.

In Rochester, the superintendent of manufacture takes the same interest in gas unaccounted for that I do. The result is our leakage is very low. The actual amount of gas leakage for the year 1910 was less than in 1909, and no greater than in 1908. The average of our leakage for the three years, figured on a three inch main basis, amounts to 66,000 feet per mile of

three inch main, which I believe is low, figuring on a percentage of something about three and a half per cent.

Second, I believe the one real reason for actual gas leakage is due to excessive high pressure on the main system. Several years ago, while connected with a Detroit Gas Company, we disconnected 2,600 feet of six inch pipe, shut off all the service cocks, and tried it out by pressing gas through a test meter. Under three inches of pressure, there was absolutely no leak. By increasing the pressure to 55-10 the same main showed leakage at the rate of 300,000 feet of gas per mile of main.

Again, I think the great trouble with us is, we try to do our work too cheaply. We don't take into consideration our men that are doing the work. In Rochester we have a meeting once a month of all the foremen in the street, their helpers and drivers, and we go over these matters in detail with them and show them that what we want is to get good work to keep our leakage and distribution expense down.

We tabulate all the complaints that come in, particularly so in regard to leakage by going over them carefully.

One great trouble, I believe is, that we don't get at and repair a leak as quick as we should. I notice for illustration a case of a leak that was telephoned into our office last winter. Our street foreman started on the job quickly, came back and reported that he could not detect the odor of gas. A second complaint came in, and I went personally with him, and you could scarcely detect the odor of gas in the street, but we investigated, and we finally found a break in the main with the ends separated about three-eights of an inch.

I also believe we do not watch carefully enough the tapping of our gas mains allowing too much gas to escape.

In testing our gas services and meters we feel we ought to have our best men do the work.

The question of laying gas mains on concave blocks, I do not believe in, because if your concave blocks are put too high you have to dig out and lower the pipe and that requires careful

filling. In Rochester, we have miles of pipe passing through conduits. We took up the question of changing this, and found it meant a great deal of expense, so we now leave a space of one-half inch around the pipe and have no trouble.

I notice in this paper somewhere that he speaks of the gas leakage around an expansion joint on a bridge. We have a bridge passing over the river where we laid a twelve inch spiral pipe. We used all kinds of extension joints to stop the leakage, but it was impossible, due to the vibration of the bridge. We finally purchased six feet of twelve inch metallic hose and put one piece in at each end of the bridge, which allows for expansion, and contraction, also vibration, and we have no further complaint.

Mr. Alfred E. Forstall: Toward the end of his paper, Mr. von Maur mixes things up a little by saying that no large percentage of unaccounted for gas is due to temperature conditions surrounding the meter. It is true that he has previously assumed that the amount of gas manufactured would be corrected for temperature, but there is quite a long distance between the assumption and the statement, and I am afraid that many people reading the paper would take it for granted that no matter whether temperature corrections were made or not at the works, Mr. von Maur thought no unaccounted for gas would be due to temperature conditions, which of course is very wrong. Unless the amount of gas is corrected to some standard temperature, say the mean atmospheric temperature is high in the latitude, a fairly large proportion of the unaccounted for gas is apt to be due to temperature conditions. I heartily agree with Mr. von Maur's suggestion that the best method of expressing unaccounted for gas is by taking into consideration not only the length of main, but also the number and length of the services. Most of us gave up the percentage system of measurement some time ago. I have been very much impressed in looking over unaccounted for gas figures by seeing how rapidly and consistently but not proportionally the amount of gas unaccounted for per mile of main increases with

the number of consumers per mile of main. Some English figures particularly first called my attention to it. I think the City of Glasgow, Scotland, has about the largest number of consumers per mile of main in Great Britain, and also the largest amount of unaccounted for gas per mile of main.

As to the suggestion that instead of considering the mains at all, we simply consider the number of services, and give the leakage as being so much per service this would entirely ignore the leakage which does take place from the mains. There is no question that there is some leakage in the main system and if we take only the number of services, we ignore entirely the difference between a well laid main system and a poorly laid main system, so I think the best way is to take into consideration both the length of the main and either the number of services, or their length in feet.

In regard to the suggestion made that in order to lay your mains on undisturbed ground it would be necessary to have in the gang a farmer who had been laying drain tiles all his life. I can't say that I have found that necessary. It is a very simple matter, at least it always seemed so to me, to get the ditch ahead of each length of pipe graded exactly to the line that the next length of pipe should rest on. The regular diggers brought the ditch down to within an inch or two of the proper depth. The man in charge of the gang actually laying the pipe provided with a straight edge, on one end of which was tacked a piece of wood the thickness of the joint. That end was laid in the open bell of the last length of pipe laid and this raised the bottom of the straight edge to the level of the bottom of the pipe, and then the section of the ditch in which the next length of pipe was coming was carried exactly to the grade that was being followed on that particular run, the thickness of the joint being allowed for. There was a little trouble until we had trained the men, but after they were once trained, the work went on very quickly, and we thought that it paid.

Mr. A. S. Miller: Mr. Chairman, I notice that Mr. von Maur's experience in St. Louis is to the effect that the greater

part of the actual leakage does not originate in the joints. My experience in other cities with pipes laid previous to ten or fifteen years ago has been that due to the vibration caused by the street traffic, and due to the change in temperature, the lead tends to work out of the joints, permitting the yarn to become loose and causing leaks. This is where the hubs are not provided with lead creases or where the lead creases are shallow and badly designed. In many cases the joints may be overhauled and lead driven every few years and yet they will leak almost all the time. There are very few cities in which one could make an excavation in or near a gas pipe that has been laid for ten or fifteen years without smelling gas. There is a large amount of leakage in such old pipes and much has been accomplished by the American Gas Light Association and the American Gas Institute in improving lead joints.

Lead joints can be made to-day that will stay tight and this was impossible with the majority of the pipe that was made fifteen years ago. The making of the joints in gas pipe is a matter of great importance and it is surprising that neither the author of the paper nor those who have discussed it have mentioned the importance of making good joints except under the general terms of doing good work. The suggestion is made in the paper (it is in quotation marks, but the text does not indicate the source of the quotation) that cement joints can be made tight by driving in two inches of lead.

Mr. von Maur: It is an error.

Mr. A. S. Miller: You could tighten joints temporarily with lead, but they will not stay tight. In my experience the less lead that is put in a joint the better it is. The joint should be filled with yarn, leaving only sufficient room for enough lead to hold the yarn in place. From one and one-quarter to one and one-half inches should be sufficient.

I made some years ago a number of experiments to determine what effect motion will have on lead and yarn joints. Joints were made with plugs in hubs having different forms of lead creases, and the plugs were jacked back and forth in the

hubs until the joint between the lead and the surface of the pipe was broken, leaving space for a leakage of gas if the yarn was not gas tight. These experiments demonstrated that where the hub was so designed as to hold the lead in place and where sufficient yarn was used and properly packed, the plug could be moved back and forth many times without causing a leak. On the other hand, if the hub were not designed to hold the lead in place, or if the yarn were insufficient in quantity or improperly packed, it took but little motion of the plug to cause leaks. In the case of cement joints the problem is a different one and as much cement should be put in as is possible.

I agree with the previous speakers that percentage is not a safe or satisfactory standard for measuring leakage. There might be several companies, each selling the same amount of gas, that would vary as much as one hundred or two hundred per cent. in the number of services, in the mileage of mains, or in the number of meters. In such case the loss per mile of main, per meter or per service might be the same, while the percentage of loss based on the sales would vary greatly.

A. Gordon King, Brooklyn, N. Y.: I have read the advance copy of Mr. von Maur's paper with a great deal of interest and would like to quote some of my own experiences. In speaking of "barring for leaks" I cannot agree that it "will only show the existence of leaks of considerable magnitude." On the contrary I have found that by the use of bars, together with a leak indicator, it is possible to locate a very small leak, and furthermore to drop almost directly over it, thus saving considerable time, expense and trouble in unnecessary excavation. And this too in a soil "that not only did not very readily allow gas to pass through it" but also possessed the rather unusual property of deodorizing the gas, so that a leak did not make its presence known by the usual offensive odor.

In the particular system I have in mind the gas unaccounted for was extremely high and it was decided to bar over all the mains and service connections. When the location of the main was unknown an electrical "wireless indicator" was used. With

this instrument, by means of a current from the secondary wires of a portable induction coil, together with a suitable receiver, it was possible to locate the position of the main very accurately, except in cases where escaping electricity from the street car rails entered the field.

The drilling was done by light steel bars, provided with an enlarged head, squared to fit a wrench or handle. These were driven down close to the main, withdrawn and the indicator placed over the hole. The pointer of the indicator shows in a short time if there is any gas present, and by the speed of its movement indicates approximately how close one is to the leak.

The instrument, the action of which is based upon the well known principle of the diffusion of gases, consists of a small circular wooden case containing a flexible metallic envelope or chamber, to which a porous clay diaphragm is attached. When in the presence of gas the hydrogen of the gas diffuses through the diaphragm very rapidly into the chamber, which in turn communicates with the pointer on the dial by a quadrant and suitable gear. The instrument was patented as long ago as 1865 by George Ansell, and when carefully and systematically used is of great value.

As to the method of repairing leaking cement joints, I found that cutting out the cement with properly shaped chisels and hooks, and recaulking with lead wool was fairly satisfactory. The majority of leaking lead joints were found to be insufficiently caulked on the bottom, thus emphasizing Mr. von Maur's fourteenth rule that thorough inspection and supervision is necessary to insure work of a permanent nature.

Another point observed in nearly every case where a joint had to be recaulked in rocky ground was that before caulking could be commenced the rock of the original ditch had to be cut deeper, thus showing that the leak was primarily caused by the bell hole not being cut large enough to enable good work being done under the pipe.

Whilst the majority of leaks were due to faulty joints, both cement and lead, several were due to the rusting out of unused

or "dead" services. These were cut and the main plugged. It is a very safe policy to insist upon this being done in every case, where a service is abandoned, as a very likely source of future leakage is thereby removed.

In the case of broken mains the cause was several times found to be due to insufficient "bottoming" of the original ditch, whereby the pipe was laid on a sharp rock projection which apparently caused a fracture as soon as a heavy weight passed over the road surface. And on account of the deodorizing soil already mentioned these leaks were not discovered until the bars and indicator were employed.

THE CHAIRMAN: Is Mr. Speller here? Mr. Forstall suggests that Mr. Speller might say something on this subject.

MR. F. N. SPELLER: There are two things in Mr. von Maur's paper that interested me particularly. In the first place, the experiments and conclusions on the question of the relative difference between bare wrought iron and steel pipe under corrosion. Mr. von Maur's test may be classed as a practical corrosion test, and from investigations which our research department have made during the past year on cases of corrosion where both iron and steel pipe were exposed together, I feel perfectly safe in saying off-hand that one hundred similar comparisons could be added, all pointing to the same conclusion. The fact having thus been well settled in so far as pipe is concerned that between steel and iron as a class there is no perceptible difference in durability, we are forced to the conclusion that as both deteriorate altogether too fast under some modern conditions, the question of uppermost importance these days is, what protective coating can we apply so as to defend the metal against the action of moisture and electrolysis. This is the second point which was of special interest to me in view of the encouraging results obtained with the wrapped paper covering. The National Tube Company has recently put on the market a coating constructed along these lines, sample of which is shown applied to six inch pipe. The outer wrapped reinforcement consists of a strip of burlap about six inches

wide saturated with a special coal-tar pitch and wound tightly on the pipe over the foundation coat which is put on so as to be as nearly as possible water-proof. We have kept in mind the important point in applying this coating, viz., that all moisture must be excluded. More will be heard as to the development of this coating in the future, and for the present I hardly think there is anything more to add than to let you know we are following up the question of the protection of pipe along these lines. I would like to ask Mr. Forstall whether in addition to the tests which he referred to in this discussion where the steel pipe proved superior to iron, both being protected with United Gas Improvement coating, he has not some records of similar tests with pipe uncoated.

MR. WALTON FORSTALL: Mr. Speller, I believe that we are now conducting a comparative test in Philadelphia as between wrought iron and steel pipe, under the direction of our Engineer of Tests. I am not sure whether it is coated, or uncoated pipe. Personally, I am interested in coated pipe only, because the coating, as I have shown, costs so little that I would hate to do without it until I had found from at least twenty years experience that uncoated pipe had as long a life as the coated kind. As I cannot get this experience on a large enough scale to satisfy me, without risking the chance of early corrosion of many services, I am continuing to use coated pipe.

THE CHAIRMAN: Any further discussion?

MR. VON MAUR: Mr. Chairman, I believe the Supreme Court has ruled that everything must be reasonable.

It would be unreasonable to expect me to keep in my head all of the various questions asked. I think there are about fifty of them, but I think I can answer them satisfactorily because most of them were due to misunderstanding. As an illustration, I have an item here of "broken by sewer." We might have a sewer break a pipe that we laid last year on account of the sewer being laid on the pipe, so it does not follow—it is not unreasonable at all. Everything stated in this paper that is

stated as a fact is a fact, and whenever you get a little data like that and you accept it as fact you finally find it inconsistent.

Now with reference to some of the remarks by Mr. Alfred Forstall on temperature. What I referred to there was of course that the gas should first be reduced to say sixty degrees, as we do here in St. Louis. Then, with gas reduced to that standard, you have a variation during the winter and summer, and if you will look at the leakage curves, you will find that the summer months are always low. What is it, if it is not the meters and the temperature. Take a meter in a hot cellar, of course it may have a slight variation from one in a cold cellar. yet the average conditions throughout the year, I do not believe makes very much difference, and that is particularly important for the works man, because when you go to the works man he tells you exactly where the leakage is. It is of course in the variation of temperature.

About the impracticability of laying pipes in undisturbed ground, that may be due to the character of the ground. In St. Louis we absolutely lay our pipe on an undisturbed ground. We have a clay here that is very hard to dig and we can smooth it off like a stone; the largest size pipe we put down on block and the pipe rests on that block and also on the ground. Now the point is, how will you make it do both. Suppose there are two inches under your pipe, and it is laid on the blocks, it is a simple matter to throw sod dirt on and pound it down so that you get the benefit of the ground support.

Take for instance the twenty-four inch pipe which weighs a ton. If you get a half a ton on each block, you have a concentrated load. Now if there is a slight space, say the eighth of an inch in between, as soon as the blocks set the eighth of an inch, they immediately get increased support from the earth.

About those leaks and as to making service connections and broken mains and all that sort of thing, where large quantities escape in a short time, if you figure that out, you

will find it is a very small percentage of the total. That is the reason I put that little piece of poetry at the beginning of my paper. If you make a test of service pipe, say a block of main 500 feet long, and watch the meter move in one hour one foot, it looks as though it is a pretty good main, and yet it loses 87,570 cubic feet, and I could double that, not because there is anything wonderful about it, but just to accentuate the tremendous quantity that escapes where the leak is sustained. You take a leak one fortieth of a cubic foot per hour and you cannot smell it, you cannot light it, it would be about a quarter as large as one of these No. 73106 lamps (I don't know whether that is the right number of the lamp or not), but it is very small. Just take a few minutes and figure, assuming a certain number of hours burning, and burning all the time, and measure it on a meter and see what you get. The same way with the lamp that is supposed to burn three feet per hour. Now we have about twenty thousand lamps in St. Louis, they are all put on the controller and we test these periodically—I forget the number of tests, I think the paper here put it at about 18, and the average of these was practically perfect. Assume a very small leak at that end, and you will find it will run up into tremendous figures during the year.

Regarding those joints where the cement is put in, and the lead afterwards, I understood later that in the public service calculations, (I believe Mr. Hellen gave me that information) they tried all kinds of joints, in high pressure mains, and I believe he said they had gone into twenty inch mains now, and that was the only joint that is satisfactory. I don't know whether that is true, whether the experiments have been going on long enough to get a correct estimate or not, but it was in line with what you were nibbling at.

About vibration, if you recollect in the paper on cement joints which I read in Cleveland some years ago, I mentioned something with reference to elasticity in cement joints. I put a block of four inch main down here in the heart of this

city, two feet away from the rail of two railroads both of which run twenty-five trains per day. We examined them the other day, and that main is absolutely tight, even with all that vibration going on.

I want to say a word about the high pressure main tests. While there are not very many leaks in my judgment in the cast iron joints, I do not want that to apply to high pressure, especially where the pipe is of large size. Take twenty-four inch joints, and at five pounds, it is an exceedingly difficult thing to get it perfectly tight; I had an idea that if I had any more I would recommend making the joint cement, and then put on a clamp—while the cement is still fresh, I believe we have men trained now so that we can trace a joint as soon as made—and while the cement is still fresh, put on a clamp, I imagine that that cement would probably protect the rubber.

I would like to ask this question: It is a very important one, because it means money: How do you know, Mr. Forstall, when to overhaul a main? Do you simply take a street like this one outside and pick a few holes and examine the joints, or do you wait until you have some joints reported, and then follow it up until you find the leaks?

Mr. Walton Forstall: Most of our paving in Philadelphia is now asphalt, or vitrified brick, with a concrete base. Under these conditions we never hunt for leaks in any main, about which no complaints have been received. When leaks are reported, we do whatever work is necessary to stop such leaks. Of course, if in hunting for leaks, we discover that 2 inch or 3 inch main has insufficient cover, or from any information that we get by inspecting a service opening, we decide that the main is of uneven thickness, then we would probably replace such a main with a larger size.

Mr. von Maur: In that connection I will say that some of the things recommended indicate that we have not reached a state of perfection. For instance this joint I show, is shown simply to prove that it is a proper way of making it.

We have had no one do it yet; and the recess coupling that Mr. Forstall has mentioned is one thing that we have in mind, and I believe that we will use it as soon as we can.

THE CHAIRMAN: Gentlemen, the next paper is Mr. Batten's paper, "The Flow of Gas in Mains."

MR. J. W. BATTEN: I am very much disposed, Mr. Chairman, to save the time of this convention as much as possible, but unfortunately I have not made such a satisfactory digest of this paper as to make it sufficiently intelligible, and I am afraid I will have to read it in its entirety. I will read it as rapidly as possible.

THE FLOW OF GAS IN MAINS.

Lacking a more comprehensive title, the above will supply an opportunity to describe the necessity for the measurement of the volume of gas flowing through a given main, together with a method for readily and with reasonable accuracy and speed obtaining such information.

The first requisites of progress in any direction—engineering or otherwise—is accurate information, reduced to some absolute numerical basis, regarding present conditions and achievement. With this as a basis of argument, intelligent discussion is possible, and a speedy and accurate solution obtained. It is a safe venture that all the unknowns in the problem of gas distribution from the standpoint of the actual delivery of the mains "in situ" have not been determined. The unknown, to which we wish to call attention, is the actual velocity of gas in our distribution mains as they lie, and to possibly stimulate interest in an already well-known method of measuring fluid volumes.

Certain well-known fundamental laws, such as those incorporated in the so-called Pole's formula, have ultimately and finally decided the size of mains and services. The drop in pressure permissible under a given assumed maximum consumption, and with gas of a given gravity, furnished the criterion by which judgment of the adequacy of a given pipe line was determined. In the large proportion of distribution sys-

tems almost all mains are ultimately connected with all others, and frequently two or more feeders from the source of supply carry gas to substantially the same territory. In such cases the break in pressure found over a given distance gives information which is not only inadequate, but which frequently is distinctly misleading. Break in pressure is caused either by actual demand on the capacity of the main or by decrease in its effective area due to the presence of water, naphthalene, or other foreign material. If we could see into our mains, it is quite unlikely they would much resemble the elevation drawing. On the basis of such unreliable information, territory might be reënforced where in reality existing lines should amply fulfill the demand. The desirability of following from year to year or from season to season the variation in the location of the area of maximum or minimum consumption is obvious.

Ordinarily used accurate methods for the measurement of gas volumes such as the wet meter are obviously inapplicable to such a situation. In the same category must be placed the venturi tube which, while it offers an accurate method of measurement with simple calculations, it is quite impossible to place one in every pipe line whose velocity might be desired. The anemometer is a completely discredited piece of apparatus from the standpoint of accuracy.

The inventor Pitot gave his name to the tube which he made and which he described before the French Academy of Sciences in 1732, giving to it the formula for falling bodies: viz., $V = \sqrt{2gh}$, which is also that for Toricelli's theorem for the velocity of issue of water from an orifice. This compact, simple, and accurate measuring device consists essentially of a plain L shaped tube placed in and directed against the flow of the fluid. Where the flow to be determined is that of the liquid, the velocity is a measure of the height "*h*" of the liquid in the tube above static level. (See Fig. 1.) Undoubtedly the very simplicity of the device prevented its general acceptance as a measuring apparatus of merit. It was not until about 1850 that D'Arcy, a French Hydraulic

Engineer, applied it directly to the velocity of flow of water and discovered it to be an instrument of precision, supporting, also, Pitot's original contention that the correction factor was unity and unvarying.

The first application of the use of this tube, in a form modified from that used for liquids, was made by Prof. S. W. Robinson of the Ohio State University in 1873. One of his earliest experiments is interesting in indicating the theoretical accuracy of the tube. Air, under a pressure of 4 inches, was allowed to issue through an orifice 2 inches in diameter into zero pressure. The mouth of the tube was inserted, at the center of the jet, to a point 4 inches inside of the tank and gradually withdrawn along the axis of the jet to a point 1 or 2

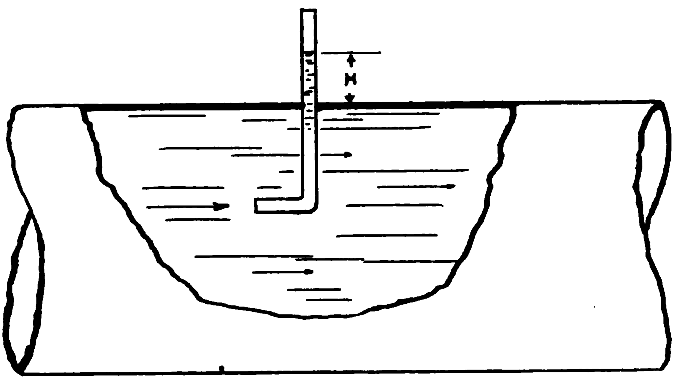


FIG.-1.

inches outside of the plane of the orifice of issue. During this operation the pressure indicated by the manometer remained precisely the same. At the point 4 inches inside the tank the pressure must have been wholly static while 1 inch outside it must have been wholly dynamic. At some points intervening it was undoubtedly a summation of the two. As the potential energy of a particle of gas decreases, its energy of motion increases, their sum being constant. Hence, when you eliminate the static pressure, the pitot tube will indicate

accurately the velocity pressure where the fluid flows through a frictionless orifice from a higher to a lower pressure.

Since Prof. Robinson published his results in 1886 a large number of ingenious and interesting experiments have been performed, establishing the accuracy of the tube. Considerable doubt existed for some time as to whether the formula $V = k\sqrt{2gh}$ was the correct one, some results seeming to point to pressure in the tube being $\frac{v^2}{g}$ instead of $\frac{v^2}{2g}$. That $\frac{v^2}{g}$ gives too great a value for the pressure may be deduced from consideration of the fact that, when a continuous stream strikes normally on a plane surface equal to its cross-section, it cannot be reflected parallel to the surface. As soon as the normal velocity is diminished, the cross-section is increased and part of the fluid is pushed out of the column.

The theoretically correct formula, viz.—$V = k\sqrt{2gh}$, having been obtained, it seemed possible that varying forms of orifices might have considerable effect on its valuation. The work of Boyd and Judd as published in the Engineering News, March 31, 1904, demonstrated that the form of the tip within very wide limits did not influence the velocity reading.

The net conclusion is that the pitot tube is a precise instrument, capable of considerable diversity of shape and withal possessing the very meritorious properties of being simple, easily reproducible, compact, readily transportable, and in addition, having a reasonable degree of accuracy.

The distribution system where the tube was to be used consists briefly of dumping gas from medium pressure distributor mains into the low pressure system by regulators, coupled with a small proportion of the output distributed direct from holders. It was found advisable to measure the amount of gas passing through some of these at various seasons and at peak load, and was intended to be continued with a view to assisting in the determination of the size and character of main extensions. It was recognized at the outset that the velocities found in low pressure distribution mains would lie probably between 5 and 20 feet per second, whereas, almost

all of the work done in this connection has been with velocities considerably greater, up to 200 feet per second. This condition would require either a very sensitive gauge or a tube whose value was much less than unity, or both. The first pitot tried was of the traditional form shown in Fig. 2, consisting of an inner tube of brass 3/16 inches O. D. and 1/32 inches thick surrounded by the static pressure end of 3/8 inch tubing 1/32 inches thick and with a slot 1/16 inches by 1¼ inches on the under side of the horizontal part. The pressure gauge used was of the form shown in Fig. 3—a practically 10:1 gauge. This combination was soon discarded as the tube was of such form that it could not be readily introduced into the main. Moreover, it had a value of approximately unity and in conjunction with the 10:1 gauge, gave a reading so low as to introduce considerable error. Effort was then

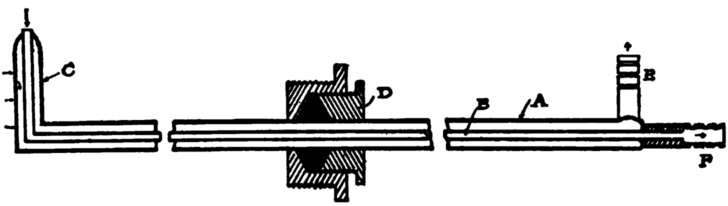


FIG. 2

TUBE OF STANDARD SHAPE AND DIMENSIONS ORIGINALLY USED.

concentrated on securing a gauge sufficiently sensitive and reliable. It must also answer the requirement of being readily set up on the street. The well-known principle of the Segur gauge seemed to offer the best solution, and an attempt was made to make use of a special type of this gauge described by Mr. W. A. Baehr in a wrinkle published in the 1904 proceedings of the Ohio Gas Light Association. This proposed to take advantage of the travel of a pellet of mercury in a horizontal tube of small bore, which pellet separated two bodies of fluid in vertical vessels of diameter comparatively great relative to the bore of the small tube. This gauge is shown in Fig. 4. The difficulty in the way of its successful operation lay in the considerable inertia of the mercury pellet,

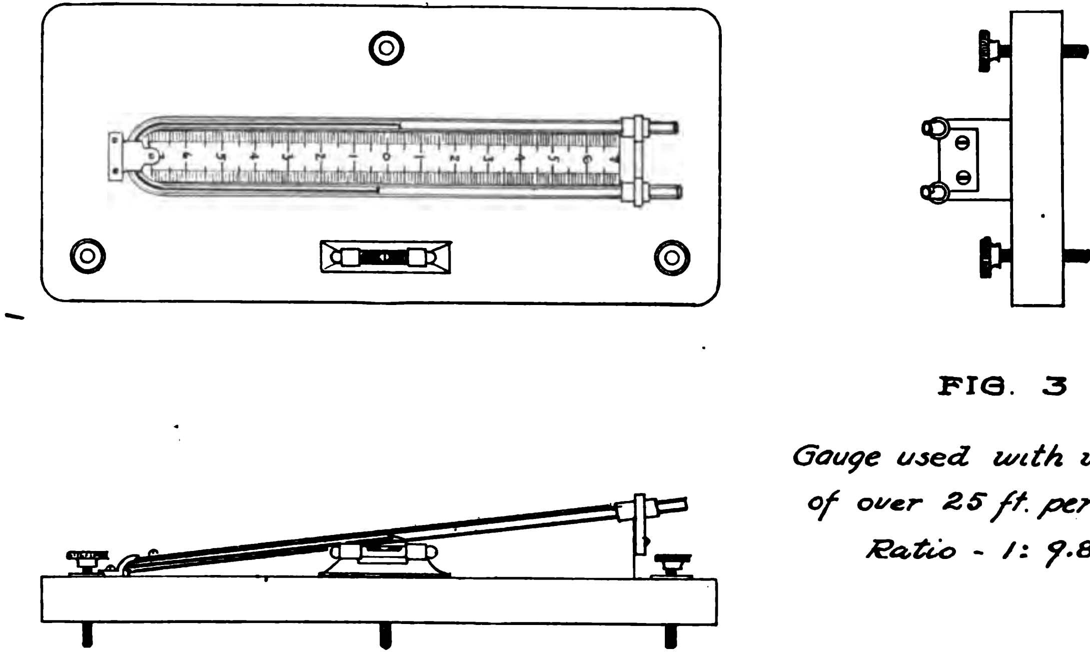


FIG. 3

Gauge used with velocities of over 25 ft. per sec.
Ratio - 1: 9.88

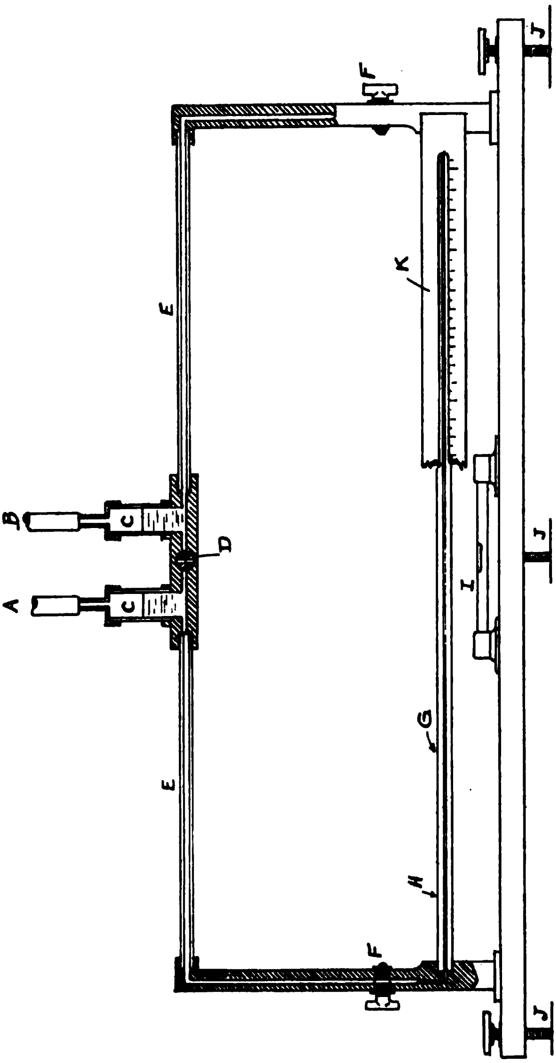


FIG. 4. Differential pressure gauge for pitot tubes.

requiring an excessive differential to drive it in either direction from a fixed position. A pellet of colored kerosene, used instead of the mercury, did not possess the objectionable feature of the latter, but instead proved ineffective due to the impossibility of preventing its ultimate mixing with the water on each side of it.

A Segur gauge of the standard type shown in Fig. 5 was

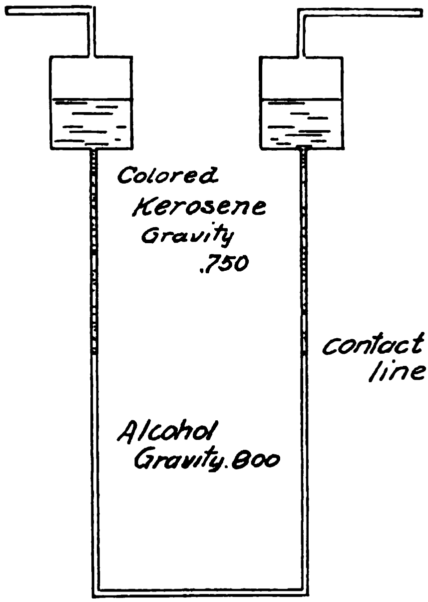


FIG - 5
Standard Type of
Segur Gauge.

made up, various combinations of liquid being used in an attempt to find two whose surface tensions were sufficiently far apart to prevent mixing, and on the other hand, possessing a gravity nearly enough alike to satisfy the condition of delicacy. After trying anise seed oil, which has a gravity of 0.998, with water, and various gravities of kerosene with alcohol, it was found impossible to obtain a satisfactory working

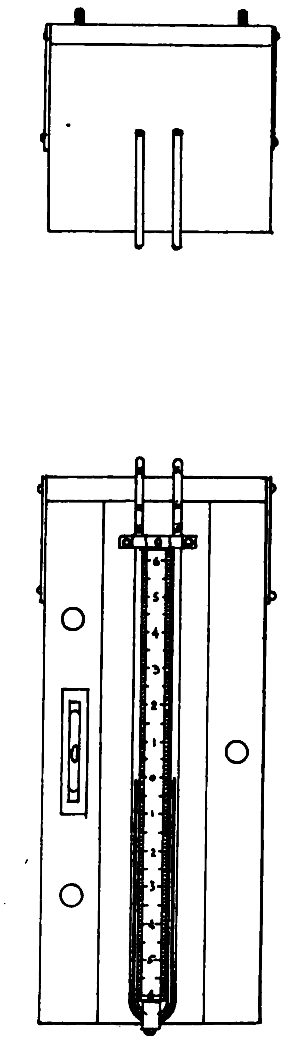
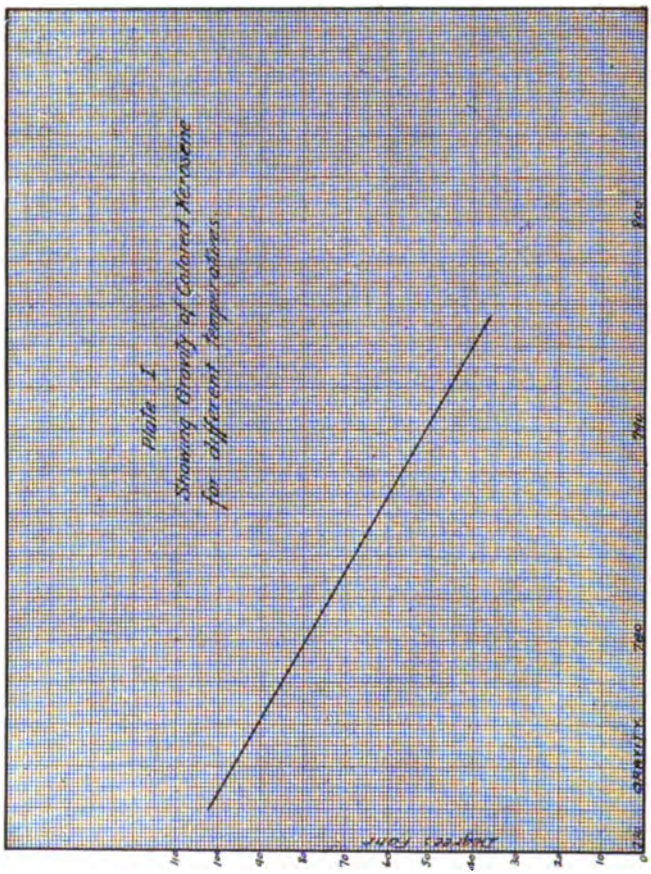


FIG. 6

GAUGE FINALLY ADOPTED

RATIO- 1: 49.4

meniscus between the two liquids separated in gravity by less than 5 per cent., any less differential producing an indefinable meniscus when either side of the gauge was subjected to an impulse of pressure. This is evidently the limiting condition



of practical sensitiveness of the gauge and, as greater delicacy was required, recourse was had to the inclined gauge of the form shown in Fig. 6. It was constructed of ⅛ inch glass tubing, which with kerosene of an accurately determined gravity at various temperatures, permitted close observations. Calibration of kerosene used in calculations is shown in Plate I.

The calibrations of this roughly 50:1 gauge were made as follows: An inclined gauge of roughly 10:1 was calibrated against an ordinary U gauge containing water, while in the inclined gauge was placed mercury of known gravity. A value thus was obtained of 1:9.88 for the inclined gauge. In turn filling this with water, and the roughly 50:1 gauge with mercury, the value of 1:49.4 was obtained for the gauge to be used in future determinations. This value was subsequently checked by the use of another similar but much longer gauge.

Having obtained a sufficiently sensitive and accurately calibrated gauge, it seemed best to use for determinations a tube

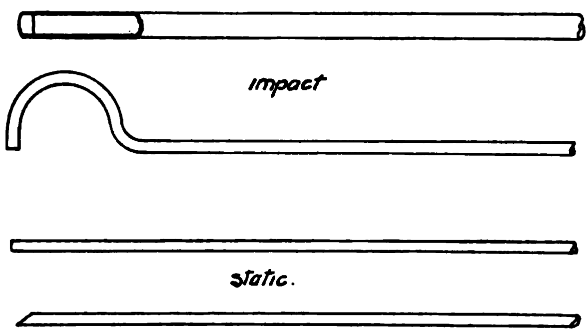


FIG-7.
Various static and impact pressure openings used to discover the pair capable of giving widest deflection of manometer.

giving the widest manometer deflections for a given velocity. Tubes having static and impact pressure openings such as those shown in Fig. 7, along with many others, were tried, and the combination shown in Fig. 8 was the one finally selected. Tubes requiring a large tap in the main to permit of their entry were rejected as it was hoped to use the tube on the street in the manner shown in Fig. 9.

The procedure, preliminary to making a determination, is as follows: The main is exposed and tapped for 1 inch standard pipe, the inside diameter of the pipe being carefully measured. The presence of water or sediment is noted with its

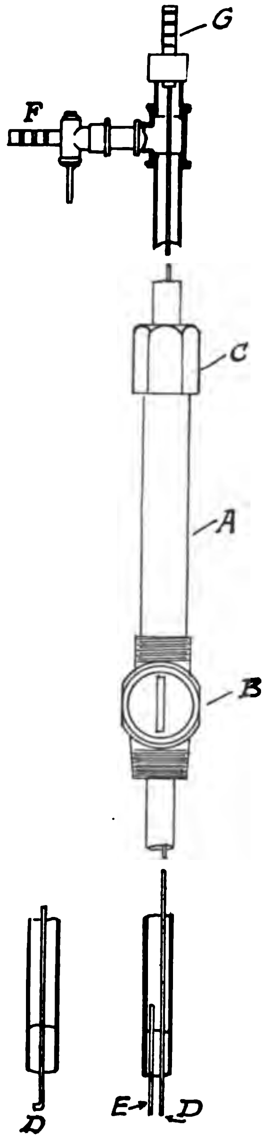


FIG. 8.

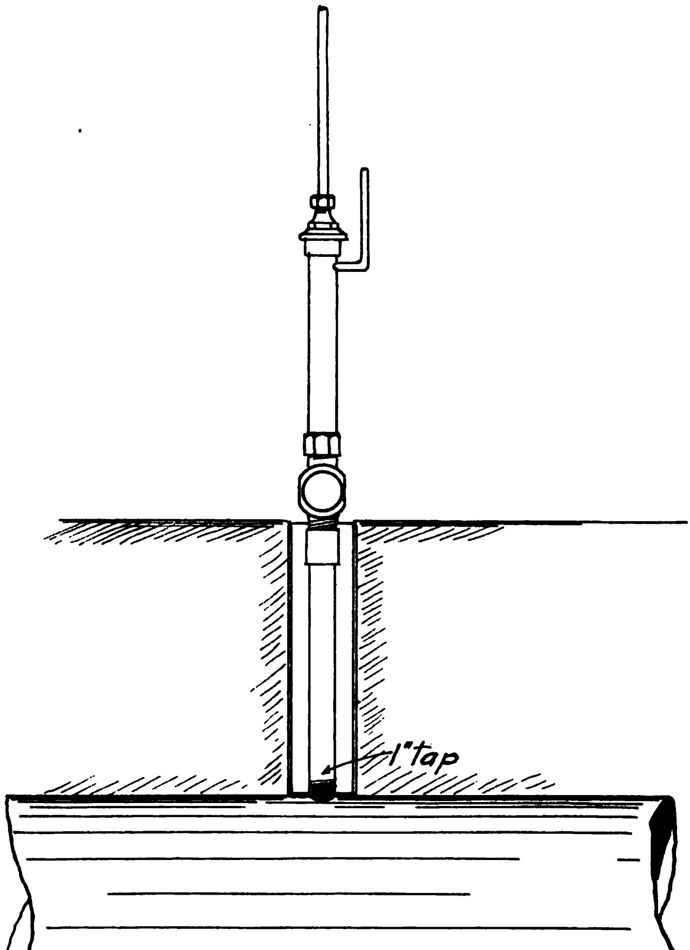


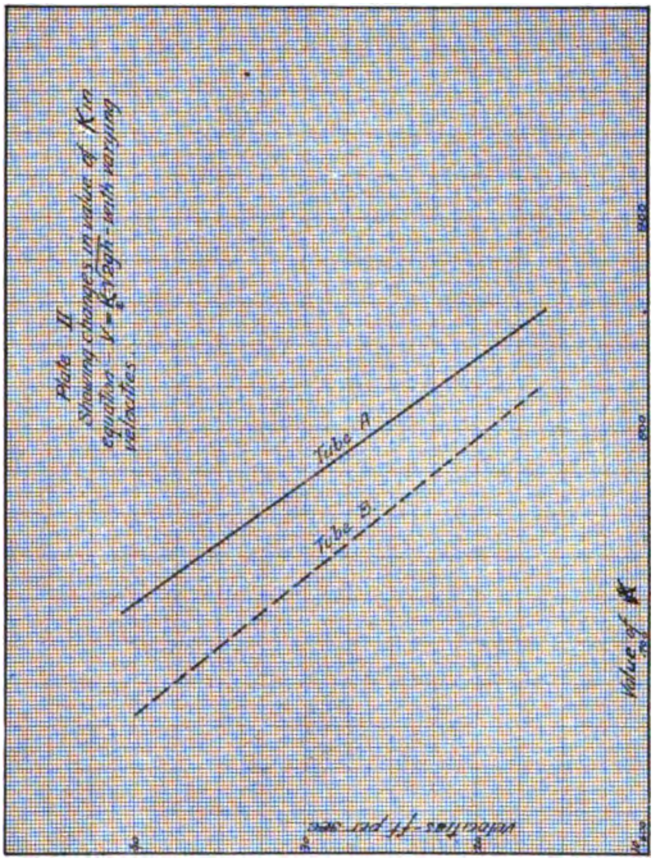
Fig- 9

amount, this restriction of area being taken into account in the calibration. The 1 inch pipe is run to the surface of the ground, capped, and surrounded with a gate box. When ready to make the traverse, the 1 inch corporation cock E, to which the stuffing box A is attached, is screwed on and the tube inserted into the main by opening the cock.

The value of K in the equation $V = K \sqrt{2gh}$ was obtained by placing the tube in a 24 inch main in series with a tested wet meter. The diameter of the main being accurately determined, the tube was inserted into it through the stuffing box. The main was divided into six or more equal concentric areas and a forward and backward traverse made, pressures being taken at the center of each annular ring, which pressure was assumed to be a measure of the velocity throughout that ring. The number of rings, into which the main may be divided, may be increased to any desired number with some slight increase in accuracy. However, in a 16 or 24 inch main 12 readings on each traverse give a reliable average. As the square root of the readings is proportional to the flow, the average velocity is obtained by averaging the square roots of the readings obtained. A specimen calculation is appended to this paper. After a number of determinations and observations were made on the street, opportunity presented itself to calibrate the tube at other velocities and in other mains. The curve showing the changing value of K with changing velocity is shown in Plate II. It appears that, while the pitot itself accurately shows the velocity head plus the static head, the variation in aspiratory effect on the static end, with the velocity, changes the value of the factor: in short, increased velocity at actually constant static pressure decreases the reading of static pressure shown by this tube, and vice versa. Evidently then, a tube which has a value of unity, unchanging, must be used wherever there is no method of arriving at the correct velocity.

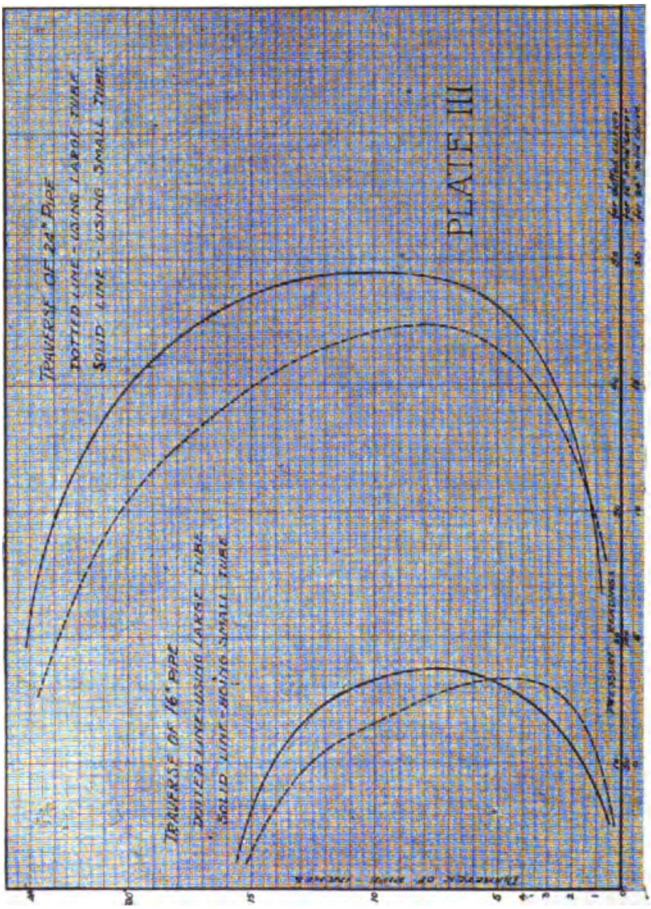
The ellipse, as the curve of pressure throughout the pipe, has been developed by a number of observers. To insure this, it appears a necessary condition that the space occupied by the

tube shall be very small compared with the diameter of the pipe. Plate III shows a traverse of a 16 and 24 inch pipe with a tube of comparatively large diameter,—about ⅞ inch in diameter and also similar traverses with a tube much



smaller. The point of maximum pressure with a relatively large tube, instead of being at the center of the pipe, is invariably at a point beyond the center from the point of entry of the tube. That this condition is brought about by the tube itself is evidenced by the fact that, if a pipe be tapped at points 90 degrees apart, the point of maximum velocity has

always the same relative position with respect to the point where the tube is admitted. Some observers have pointed out that the loci of mean velocity lie on the circumference of a



circle 0.77 of the distance from the outside to the center of the pipe, and that the mean velocity is about 80 per cent. of the velocity at the center. It seems likely that the proximity of elbows or obstructions to the point of observation may produce eddy currents rendering this inaccurate. It is often nec-

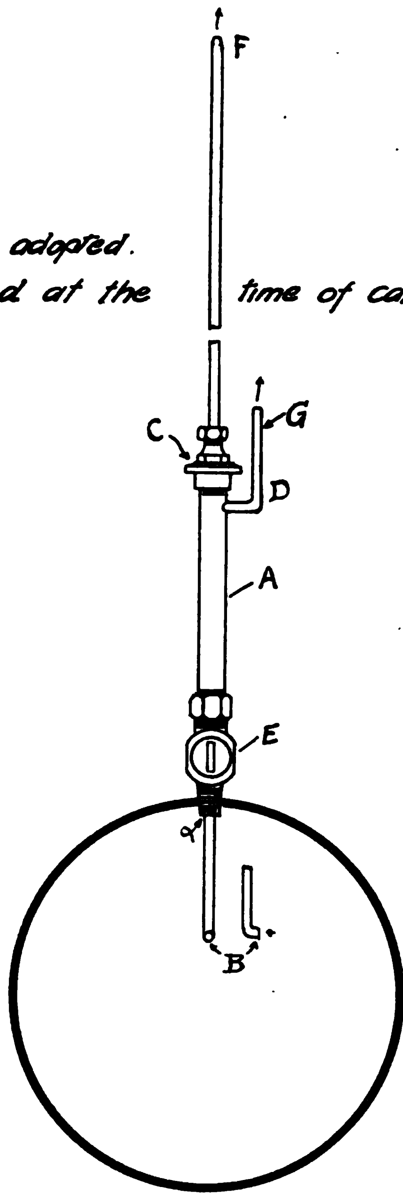


Fig. 10.

Final tube adopted.
as used at the time of calibration.

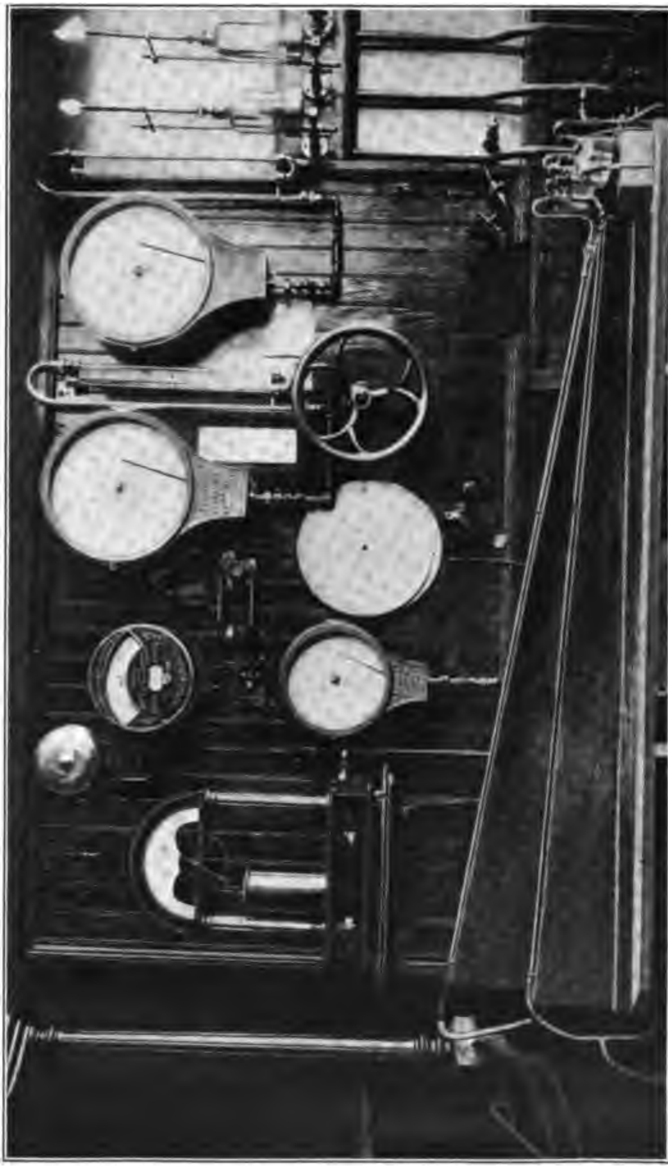
essary to traverse the pipe in two directions at 90 degrees to one another to eliminate this disturbing factor.

The discovery of the variable character of the value of K for changing velocities led to the production of the tube shown in Fig. 10 which has been found to have a value of 1.01 at all reasonably low velocities up to 20 feet per second. It is not unlikely that it would be increasingly in error at velocities above this. The static pressure is taken from the 1 inch tap at the edge of the pipe where theoretically the velocity is zero.

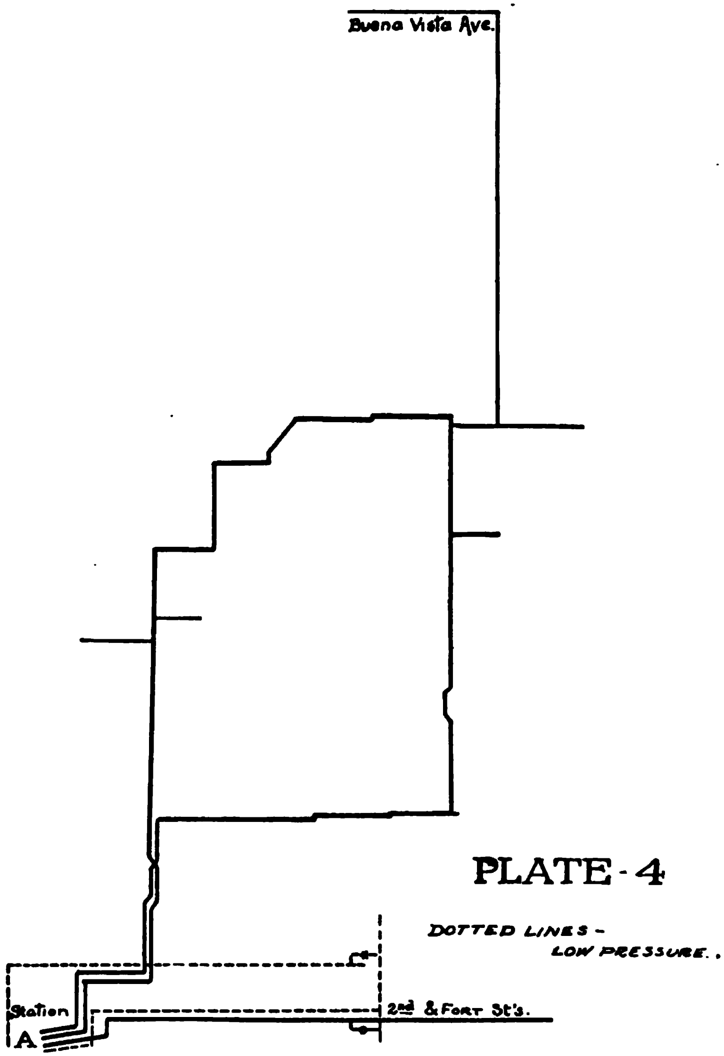
This form of tube and gauge offers a method of easily making frequent tests at the same point, with no exposure of the main after the first determination of its internal diameter is accurately made.

As intimated in the beginning of the paper, other applications of the principle may be found, two of which will be sufficient for illustration.

Two 16 inch lines from Station A, Detroit City Gas Company, carry gas under regulated holder pressure through two parallel streets one block apart into the downtown section two miles away. On one occasion at peak load in the evening when local pressure was somewhat increased at Station A, a serious oscillation was noted at the regulator manholes at Fort and Second Streets. This regulator at the time, however, was not passing gas due to back-up from these two low pressure mains connected to its outlet. See Plate IV. Obviously, the oscillation was due to water in one or the other of these low pressure lines. Recording gauges installed at suitable places seemed to point to the presence of water at a certain point about midway between the source of supply of gas and the place where the oscillation was first noted. No water, however, was found. Practically no services were taken off these lines where oscillation seemed greatest, so the main was tapped for taking over a considerable distance, simultaneous U gauge tests. This test developed nothing, as all oscillations appeared of about the same amplitude. The pitot tube placed on the line disclosed, that looking at the oscillation of pressure on the static pressure gauge, at the mo-

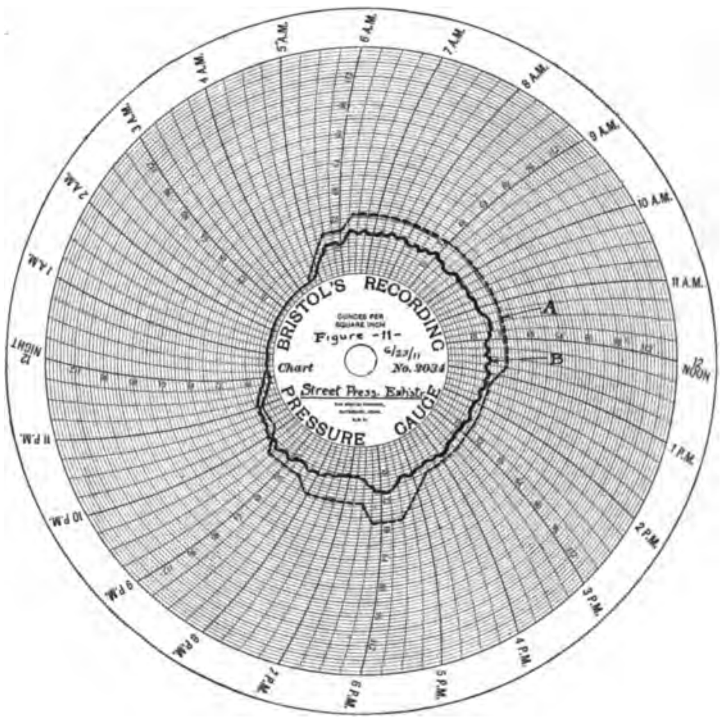


ment when the pressure increased, the differential on the tube decreased—*i.e.*, when the pressure increased, the rate of flow



decreased, showing conclusively that our observations were being taken between the source of supply and the stoppage.

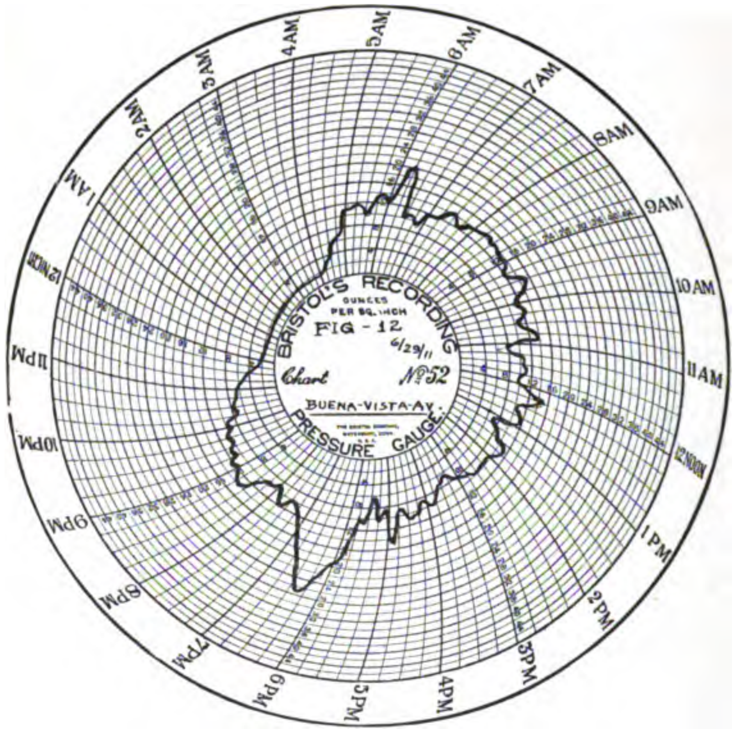
It was then merely a matter of tapping the main in a few places, finally arriving at a point where drop in static pressure coincided with the increase in flow. The water was finally found at a point where a line running out of the 16 inch and into which the latter drained had been cut off and capped some years previously, no drip having been put in. Un-



doubtedly the carrying capacity of this main had been seriously interfered with for some time, but the presence of other sources of supply prevented its discovery until it was practically full of water. Had a tube been placed on these two lines simultaneously, the wide disparity in the amount of gas carried would have been at once noted and a reason sought.

The other application, which I have in mind, is one in which not only a pitot but any differential, which remains constant

for a given flow of gas and varies in a known way, may be used. Reference may be had to the diagramatic map, Plate IV, which shows the medium high pressure pumping lines from Station A, reaching as far as Buena Vista and Woodward Avenues, a total distance of 8½ miles. The requisite pressure to keep regulators at the end of the line in opera-



tion was maintained by the Station A operator, whose instructions were to follow a predetermined chart, which might produce a chart at the end of the line like the one shown in Fig. 12. This model chart was changed as often as circumstances seemed to warrant, but usually about once or twice a month. Invariably, however, the pressure maintained had to be sufficiently high to take care of sudden storms or unusually dark or cold days. This necessitated an expendi-

ture of power at the pumping plant almost all the time in excess of the actual needs of the case, and moreover, did not even then ensure an invariably sufficient supply.

It occurred to Mr. F. L. Cross, at that time Assistant Engineer of the Detroit Company, that, as a definite relation must exist between the amount of gas being pumped and the drop in pressure from the pump to the end of the line, it should be possible, after calibration, to predict this fall in pressure, knowing the drop through a given proportion of the distance, or what would be more feasible, through a pitot tube. Unfortunately, Mr. Cross was unable to remain to carry out his suggestion which has been subsequently worked out to a satisfactory conclusion.

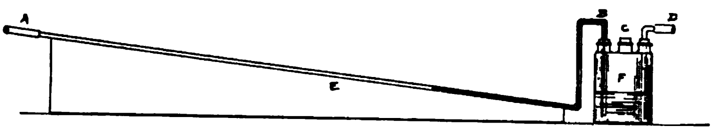
To discover whether the velocity of output at the plant was a measure of the drop in the total high pressure line, a pitot tube was inserted at the outlet of the exhausters, accurate readings being taken simultaneously every two minutes of

1. The static pressure at Station A.
2. The pitot readings at the same place.
3. The static pressure at the place where the pressure was ultimately to be maintained constant.

These results were plotted and shown on Plate V. The fourth curve shown on this plate is obtained by taking the difference of the two records of static pressure. From a consideration of this plate, it is evident that each increase or decrease in output shown on the tube is reflected in the difference of the two static pressures. It is not to be expected that they would coincide or constantly remain the same distance from one another, since the differential shown by the tube is a measure of the square of the total outflow, while the difference of the two static pressures is a measure of the sum of the squares of the amounts going out through each regulator, on the way,—only a small amount of the total output finally reaching the end of the line. This led to the placing of a tube at the inlet to the exhausters, in permanent position, such tube being one which would give the widest deflection possible with a given flow. This was piped to a suitable sensitive differen-

tial pressure gauge shown in the photograph, and in detail in Fig. 13. The gauge immediately beside it is simply a delicate mercury static pressure gauge, both under the eye of the pressure operator.

The pressure which it was desired to maintain throughout the hours of the day and evening was from 12 to 14 ozs. To calibrate our installation, a water pressure gauge capable of holding a pressure of two pounds was placed at Buena Vista and Woodward, and the observer there instructed to telephone to Station A every twenty minutes a record of the pressures which he took every five minutes. In the meantime, at Station A, readings of the flow and static pressure were taken every five minutes, and pressures maintained there as far as



Gauge for long distance control apparatus.
FIG.-13

possible such that the desired pressure was maintained at the end of the line.

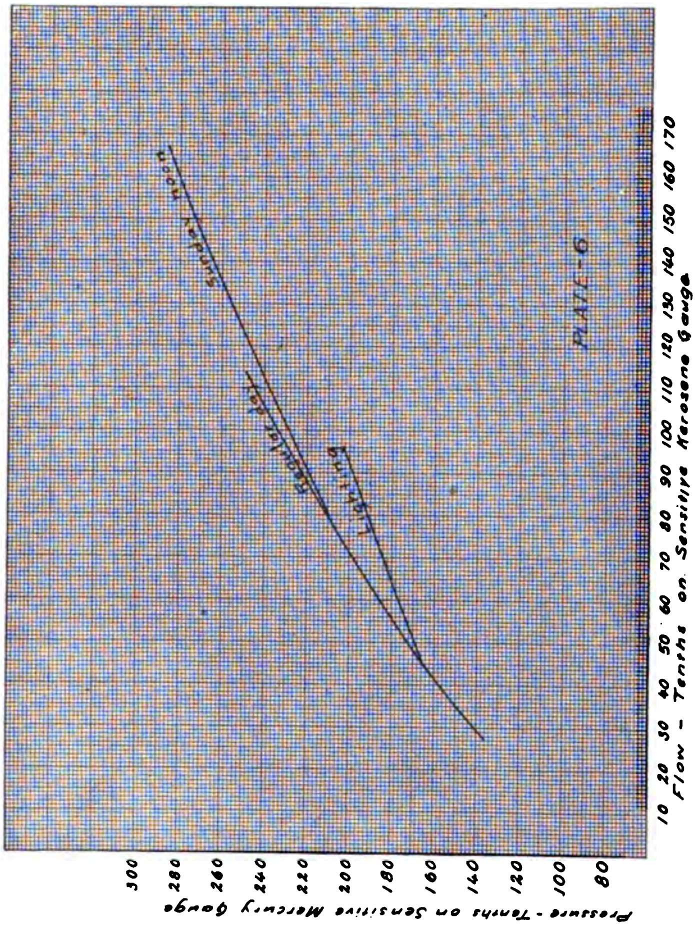
The curve obtained is shown in Plate VI. It is interesting to note that the lighting load and the Sunday noon load do not fall precisely on the curve for the regular day. Evidently the lighting and cooking gas is consumed to a greater extent on an average at a point nearer the base of supply than the industrial gas. This is exactly a confirmation of what would be expected from such a situation as ours, a large proportion of the industrial gas being consumed at a relatively long distance from the plant.

Fig. 11, A, shows the chart which, under ordinary conditions, would have been followed,—Fig. 11, B, the one actually made in an effort to maintain the predetermined pressure at Buena Vista & Woodward, while Fig. 14 shows the result accomplished. In case it seemed advisable to hold a higher or lower

pressure at the end of the line, a new calibration would, of course, be necessary.

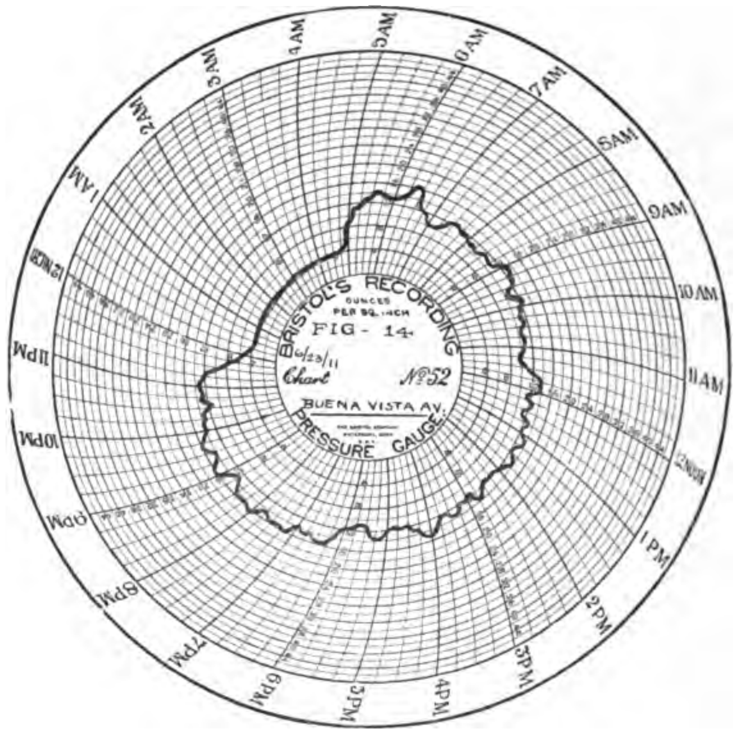
The operation of the installation proceeds as follows:—

Assume that the flow gauge reads 71 and the static gauge



200. Adjustment is perfect and the operator is assured that the pressure at the end of the line is about that desired. Assume also an increasing load. The pressure at Buena Vista & Woodward falls slightly, a fall which is at once reflected

in a fall of the static pressure at Station A since the positive pressure pumps continue to deliver the same amount of gas. For this reason, the flow gauge remains constant and the operator notes that he no longer has the proper balance,—he is below the line. He gradually increases the speed of the exhausters, increasing at the same time the static pressure and



flow, but increasing the former more rapidly than the latter until finally at, for example, a flow of 105 he has a static pressure of 240, when the conditions of equilibrium are again established. On decreasing the load the exact reverse of this procedure is followed. It is undoubted that changes in location of consumption of large volumes of gas will affect the results obtained by following the chart, but as these changes

are slow, they can easily be taken care of by re-calibration. It appeared possible that the same proportion of the total output would not be consumed in a given location, regardless of the output, but from our short experience, each section of the city consumes its constant proportion of total output regardless of the kind of weather or season or year.

APPENDIX.

Sample calibration :

In case where volume of gas passed is known, and it is required to find the value of K :

$$V = K\sqrt{2gh}$$

where v = velocity of gas in feet per second

K = the desired constant

g = acceleration due to gravity

h = the feet of gas of the pressure, temperature and degree of moisture saturation of that in the main under test, which is sufficient to deflect the manometer the amount noted on the pressure gauge

Barometric pressure	29.55″ Hg.
Static pressure	0.65″ Hg.
Temperature in main	76° F.
Percentage of moisture saturation—not taken, assumed to be	60 %
Rate of flow shown by wet meter..	151,370 ft. per hr.

A forward and backward traverse of the main was made during which 12 readings were taken each way. The square roots of these were averaged, resulting in an average reading of 1.014″ of kerosene on the 49.4 : 1 gauge.

Gravity of gas at 76° and 29.55″	0.422
Diameter of pipe	24¼″

Inches of water differential at 4° C =

$$\frac{1.014 \times 0.781}{49.4}$$

Gravity of gas at 81° F. and 30.2" Hg. is .. 0.435
Weight of one cu. ft. of gas, 60 % saturated
with moisture at 81° F. and 30.2" mercury 0.03122

Then "h" in feet of gas of quality measured is

$$\frac{1.014 \times 0.781 \times 62.425 \times 144}{49.4 \times 1728 \times 0.03122} = 2.605 \text{ feet}$$

$$V = K\sqrt{2gh}$$
$$= K \times 8.02\sqrt{2.605}$$
$$13.13 = K \times 8.02 \times 1.613$$
$$K = 1.013.$$

THE CHAIRMAN: Gentlemen, you have heard Mr. Batten's paper. Any discussion?

MR. O. H. FOGG: Mr. Chairman, there is very little on this subject that I can say that would be of interest. While I have made some experiments along these lines, they have developed nothing that Mr. Batten has not very thoroughly covered. It may be of interest, however, to confirm one point brought out by Mr. Batten on page 384, that is, that in our work we could not find that the mean velocity bore any definite ratio to the velocity at the center of the pipe, that is no definite ratio for varying sizes.

The element of disturbance that Mr. Batten thinks is set up by elbows and other obstructions I believe exists appreciably. If we were to have one continuous line, without any such obstruction or anything to create eddy currents, the figure given, 0.77, would, I believe, probably be correct.

MR. FULWEILER: I would like to ask Mr. Batten whether he has ever made use of the whirling arm apparatus in the calibration of his Pitot tubes. I believe the Armour Institute of Technology, Chicago, has such an apparatus and is prepared to calibrate tubes with it.

When we calibrate Pitot tubes in a pipe we can only approximate the average velocity, since we determine it by taking averages of averages, whereas in the case of the whirling arm apparatus we actually pass the tube at defi-

nite velocities through the air, and thus secure a positive and very accurate calibration.

There is another point which occurs to me, and that is in relation to the method Mr. Batten has adopted for determining the static pressure. He measures the pressure existing in the nipple which is tapped into the side of the main, and assumes that the pressure close to the side of the main is zero. Some experiments that we have made would seem to indicate that unless the nipple is cut off perfectly smooth and does not enter the main, that there will be set up eddy currents in the vicinity of the opening which are likely to seriously affect the accuracy of a pressure taken at this point.

I should further like to ask Mr. Batten whether in his work he has considered the use of trailing and leading tubes. This method of operating has been exploited in a number of recent articles in the technical press, and it seems to show some considerable promise. I believe there are already on the market several forms of Pitot tubes which utilize this principle.

Mr. R. G. Griswold: The electric people have made a great deal of progress in their line because it has been so easy to take readings of what current was flowing. They have apparatus, whereby, in the evening, at times of heavy load, they can, in a few minutes, determine just how much current is flowing in a given feeder. We people in the gas business cannot do that. We cannot cut a main and set a meter. But with this Pitot tube, and the other things outlined, we can determine just what the demand is, just how fast the gas is used in any particular main, at very little expense and trouble. The electric people have even done this, they have compensators for their volt meters, so that the volt meter on the switchboard at the station attached to any particular feeder shows the voltage at the end of the line. I think someone in the course of a year or two will make a device by which you can test your mains at your plant, and read pressure at some distant point in the

distribution. The pressure at the distant point will be corrected for the velocity of flow at that point, so that we can read the pressure at any point in the distribution system.

THE CHAIRMAN: Any further discussion?

MR. FULWEILER: I do not think Mr. Griswold should give us the idea that the determination of the flow of gas in a pipe with the Pitot tube is quite as simple as he makes it; in other words, that all we should have to do would be to stick the Pitot tube into the pipe and would immediately get the flow of gas in that pipe. There are a number of very important steps which have to be taken in order that the result shall be accurate. Briefly, they are, dividing the area of the pipe into rings of equal area for the determination of the velocity and static pressure at the center of each ring, and the average of these pressures. While, to be sure, this is a very simple operation, yet it takes, I should say, at least ten minutes to determine the average velocity in a pipe of any size. In one of the commercial forms of Pitot tube now on the market they have a number of inlets so placed to cross the diameter of the pipe that the resulting velocity pressure is found to be a very close approximation to the average pressure. If such a form of tube can be satisfactorily worked out, it will, of course, give us an instantaneous determination of the rate of flow, and thus avoid the present trouble of making a large number of observations.

THE CHAIRMAN: Any further discussion? Mr. Batten.

MR. BATTEN: In regard to the calibration of the Pitot tube, I might say that in order to eliminate some of the errors that must of necessity creep in, this tube is calibrated in two directions at ninety degrees to one another, in not only twenty-four inch pipe but also in sixteen inch pipe, and the assumption naturally is that two calibrations, one in each pipe, resulting in giving a common factor, will undoubtedly give a resulting factor which is well within the error of reading your gauge.

In regard to the method of calibrating the tube by means of the whirling arm, I am not familiar with the method of doing it. I was favored by Professor Gebhardt loaning us a small

tube which I was unable to use for one or two reasons. In the first place, the impact pressure opening was very small, and the fact of there being a large amount of water in the gas, very nearly to the saturation point, made it practically impossible to utilize that form of tube. I noticed, however, that the static pressure end of the tube was apparently so constructed that the aspiration effect on it just neutralized the impact pressure. In other words, it was not constructed in such a way as to give, at various velocities, the actual pressure. I was confident that that tube would not give the same value at all velocities. I may be wrong in that assumption.

As to the matter of the final tube selected, that tube was selected because it seemed to be the simplest possible, permitted the simplest method of insertion into the main, and at the same time rendered results of the degree of accuracy which was desired. Now, as I mentioned in the paper, it is quite unlikely that this accuracy would be maintained at velocities where the effect on the static pressure end would be very material if the velocity were increased, but at low velocities, say ten to fifteen feet per second, the calibration evidenced that there was practically no variation in value. The difficulty, I think, in utilizing a tube of the kind mentioned by Mr. Fulweiler is the difficulty of getting one with the value of a unity. Now, as far as my experiments have gone, they have led me to believe that it is absolutely necessary to have a value of the unity, otherwise with varying velocities that value will change. One of the charts shown in the paper here gives the variations of the value of the constant with varying velocities, and unless you get the absolute static pressure, unless the one tube absolutely gives you the static pressure, the value of the tube will not remain constant at all velocities.

Mr. Brown suggested that the tube could be utilized in connection with high pressure pumping lines. I have in mind a case where we have two pumping lines diverging at the plant and passing through the city, and finally reconverging at a distance of four or five miles from the works. The conditions

seemed to indicate that one of the lines was delivering more than its proportion of gas. Simultaneous readings in the two mains (not very far, to be sure, away from their junction point) showed us that the two mains were actually passing gas at practically the same velocity; and as the conditions seemed to indicate, roughly, that the amount of gas passed through them should be very nearly the same, it was evident to us that there was no stopping along the line.

THE CHAIRMAN: If there is no further discussion, we will now stand adjourned as to all our business, and I would ask everyone to be present to-morrow morning.

The session was then adjourned until Thursday, October 19th, at ten o'clock A. M.

Thursday, Oct. 19, 1911.
10:00 o'clock A. M.

Section B of the convention of the American Gas Institute was convened in the lower hall of the Art Building at ten o'clock A. M., Mr. W. Cullen Morris, First Vice-President presiding, and Mr. Walton Forstall acting as secretary.

THE CHAIRMAN: The first paper will be "The Centrifugal Compressor in the Manufacture of Gas," by Dr. L. C. Loewenstein.

THE CENTRIFUGAL COMPRESSOR IN THE MANUFACTURE OF GAS.

In manufacturing gas it is necessary to supply a proper amount of air during the process of gas making, and to compress the gas into gas holders or gas mains after the gas has been manufactured. For both of these purposes some form of air compressor is necessary. The object of this paper is first, to call attention to a somewhat recent development of improved air compressor which has, among other advantages, a much higher efficiency than any similar apparatus used heretofore; and second, to describe a comparatively new method of controlling the air supply to gas apparatus securing thereby an increased and more uniform output.

The rapid substitution of rotating for reciprocating machinery has been one of the most striking engineering de-

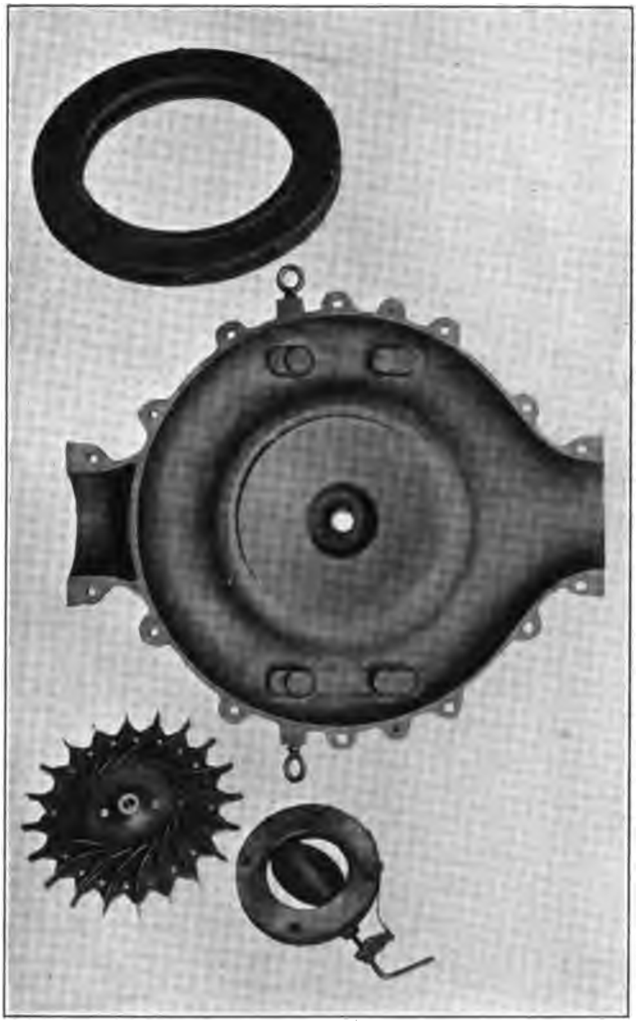


Fig. 1.

velopments of recent years. The marked success of the steam turbine no doubt stimulated the development and in-

troduction of the centrifugal pump and more recently the centrifugal compressor, so that we can say the centrifugal compressor to-day stands in the same relation to other air compressors as the steam turbine stood fifteen years ago to the reciprocating engine, or as the centrifugal pump stood five years ago to former pumping apparatus.

Centrifugal compressors can be built either as single-stage or as multi-stage units and are usually direct connected to prime movers, preferably steam turbines or electric motors, because the centrifugal compressor is necessarily a high speed mechanism. A single stage centrifugal compressor consists solely of a revolving impeller surrounded by a stationary set of discharge vanes supported in a suitable casing. A multi-stage compressor consists of two or more single stage units mounted on the same shaft and operating in series within a common casing. Fig. 1 shows an impeller, a set of discharge vanes, a half casing and a blast gate of a single stage compressor.

When set revolving, the impeller will, by centrifugal force, entrain a fluid, say air, at its inner periphery and will discharge it at its outer periphery at an increased pressure. This resultant pressure can be called centrifugal pressure. Besides this the impeller has set the air into motion, and at the outer periphery or discharge end of the impeller the air is moving at practically the same velocity as the peripheral speed of the impeller. This velocity amounts to hundreds of feet a second, and of course, represents a large amount of energy expended by the driver. It is the function of the stationary set of discharge vanes to convert this energy in the form of high velocity into pressure energy. The discharge vanes are so designed that the air in passing through the passages between the vanes is gradually reduced in speed and the energy recovered in the form of an increase of pressure. Taking for instance, any one of the centrifugal compressors illustrated in this paper we may say that possibly 90 per cent. to 95 per cent. of the energy supplied by the driver to the

compressor appears in two forms of energy in the air as it leaves the rotating impeller. Roughly speaking about one half of the available energy exists in the form of centrifugal pressure, and one-half of the energy exists in the form of velocity. In an ordinary fan or blower this high velocity air is allowed to dissipate itself into eddy currents and finally exists in the air in the form of heat. In a centrifugal compressor this energy is largely recovered in the form of increased pressure. Hence the vital difference between an ordinary fan or blower and a centrifugal compressor lies in the fact that the former has no discharge vanes and therefore does not recover any of the velocity energy generated by the rotating impeller, whereas the latter has discharge vanes which recover the larger part of the velocity energy produced by the impeller. It can be readily seen why the centrifugal compressor is so highly efficient and why this recent development of air compressor is replacing former existing types. It means that for compressing the same amount of air against any definite pressure the centrifugal compressor requires much less power hence a much smaller motor or driver than used heretofore. There are also other advantages worth considering. On account of being able to operate at high speeds this compressor is much smaller in size than any other compressor delivering the same work, and further because it can run at high speeds it can take advantage of being direct connected to high speed drivers which are in themselves smaller and more efficient than those which must operate at low speeds. The moving parts of a centrifugal compressor consist only of an impeller mounted on a shaft and supported in bearings. There are ample clearances about the impeller and if the bearings are properly designed and provided with efficient lubrication there are no rubbing parts whatsoever, hence the original efficiency of the unit is maintained after years of service. Compare this to the performance of displacement or positive pressure blowers where frequent renewals are necessary to maintain somewhere near the original efficiency and output,

or compare this compressor to the inefficient and large fans or blowers heretofore used, and it does not then seem too optimistic to predict in the near future the entire substitution of centrifugal compressors for all other forms of air compressors.

Although the initial development of this new type of com-

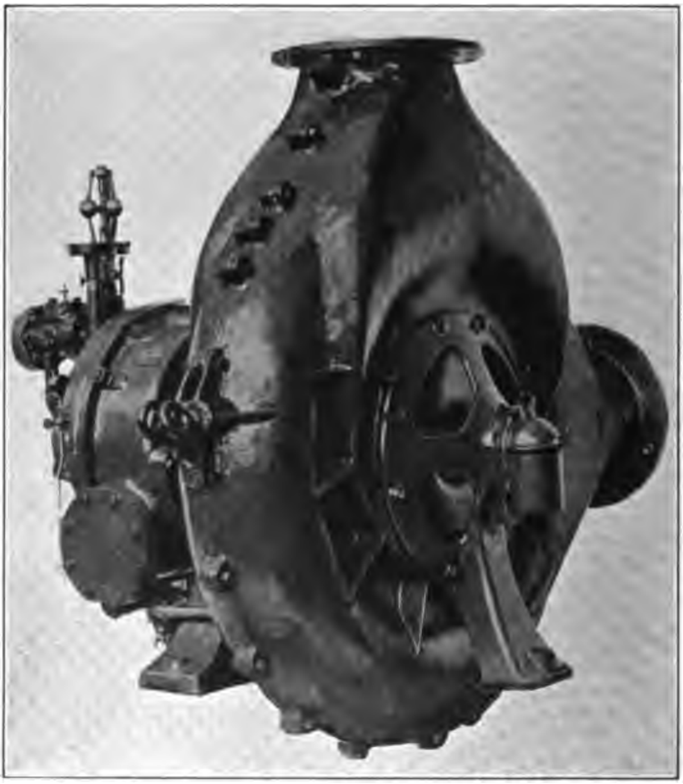


Fig. 2.

pressor was first begun in Europe, the General Electric Company started about three or four years ago to develop and introduce the centrifugal compressor in this country, and in this comparatively short space of time the General Electric

Company was able not only to build compressors of equal and higher efficiencies than those produced abroad, but have advanced the art by building the largest units that have ever been attempted anywhere. The following illustrations show

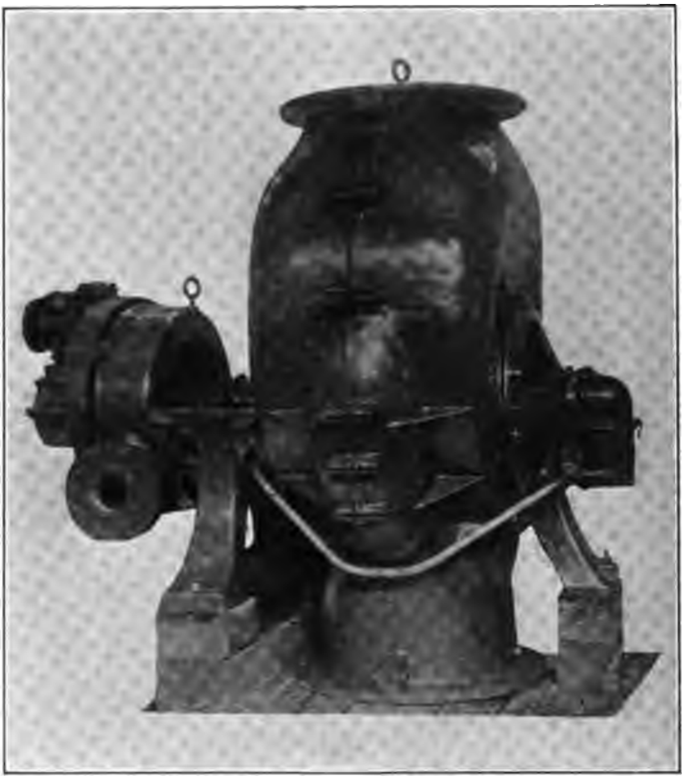


Fig. 3.

the general appearance of some of the standard single stage compressors built by this company.

Fig. 2 gives a photographic view of a turbine driven centrifugal compressor capable of delivering 10,200 cu. feet of air per minute against one pound pressure. It is direct connected to a Curtis steam turbine running at a normal speed

of 3,450 revolutions per minute. This set was furnished to the Springfield Gas Light Co. of Springfield, Mass. As can be seen the entire unit has only two bearings, the compressor impeller being supported between the two bearings, and the turbine wheels being overhung at one end. As the pressure delivered by a centrifugal compressor is directly proportional to the speed of the impeller, practically constant pressure is maintained no matter what the volume of discharge if the turbine is kept running at constant speed. In order to change the pressure delivered by the set, the turbine can be speeded up or down so that this piece of apparatus can be said to force air or gas against a constant resistance or pressure no matter how varying the quantity demanded.

Fig. 3 shows another centrifugal compressor direct connected to a steam turbine and capable of delivering, in this case, 4,200 cubic feet of air per minute against two pounds pressure. This set also runs normally at 3,450 revolutions and was furnished to the United Gas Improvement Company of Philadelphia, Pa. In general design it is similar to the previous set, the only changes being that the air intake and air discharge are set at 90 degrees to each other instead of being opposite as in the previous figure.

Fig. 4 shows two centrifugal compressors driven by induction motors, furnished to the New Amsterdam Gas Company, New York, N. Y., and each set is capable of delivering 3,600 cubic feet of air a minute against a pressure of 0.9 of a pound. This photographic view illustrates how conveniently these sets can be located and the small amount of floor space they require.

All the compressor sets described up till now are units built to operate against a constant resistance or pressure, and are known as constant speed apparatus. There are cases in which the air should be delivered with constant volume against a continually varying resistance or pressure, and such class of apparatus is known as constant volume compressors. As far as the compressor is concerned, the constant volume

unit is exactly the same as the constant pressure unit. The only thing necessary to change a constant pressure set into a constant volume set is to add the so-called constant volume governor which automatically controls the speed of the driver,

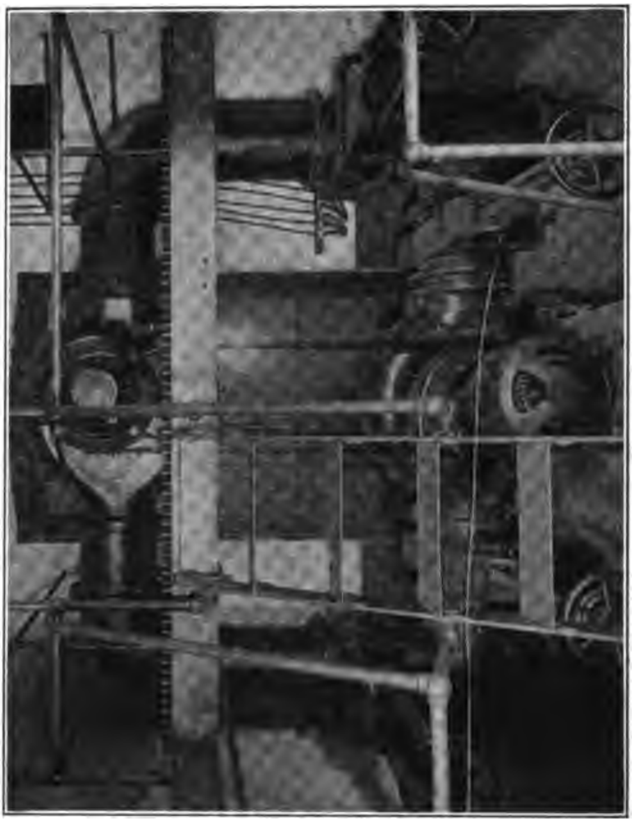


Fig. 4.

thus varying the pressure delivered by the unit and maintaining a constant volume of air delivered.

It is to this type of apparatus that I would like to call your particular attention, because of its excellent application in the manufacture of water gas. In this case the air should

be delivered to the gas generator under constant volume and not under constant pressure, as is generally done. It may be interesting to analyze just why this air is needed and how it should be delivered in order to obtain most efficient operation. In the manufacture of water gas, the generator is filled with a deep fire of coal or coke, and a blast of air is admitted in the bottom of the generator under the grate, and passes up through the fuel. The oxygen of the air unites with the heated carbon to form carbonic oxide. The nitrogen is not affected. These two gases, carbonic oxide and nitrogen are termed the products of partial combustion, the meaning of which is that if more oxygen be added the carbonic oxide will ignite and burn to carbonic acid. These products of partial combustion are thus burned in the carburetter and superheater by admitting air from the blower. The result of this combustion is intense heat, which is taken up by the loose fire-brick, or checker-brick, with which the carburetter and superheater are filled. The resulting carbonic acid and nitrogen-products of complete combustion—then pass off to the atmosphere through the stack valve. The degree and distribution of heat in the carburetter and superheater are entirely under control, and can be adapted to the character of the oil used for carburetting. When the temperatures in these various shells are at the proper point, the air blasts are shut off, and all combustion ceases. The stack valve is then closed and steam is admitted under grate in the generator. The passage of this steam through the highly heated fuel produces non-luminous water gas. As this gas enters the top of the carburetter it meets a spray of partially vaporized oil. The gas and the oil vapors pass together over the highly heated surfaces of the checker-brick, and the oil vapors are gasified and fixed in the presence of the non-luminous water gas. The result is a thoroughly fixed and permanent illuminating gas, which passes on to be scrubbed, condensed and purified in the usual manner. This period of gas making is continued until the heat in the apparatus is reduced to a point where

it is not advantageous to continue. The oil and steam are then shut off, the stack valve opened, and the process of blasting and heating up is repeated. Alternations of this heating up, or "blow," and of gas making, or "run," are continued, each of which hardly ever exceed six or eight minutes in duration, until it is necessary to stop and add fuel, and at longer intervals, clean the fire by removing the slag.

As can be seen in the above described process, air is simply introduced to assist combustion; that is, a certain weight of oxygen is required for combining with the heated carbon in the generator in order to form carbonic oxide, and a certain weight of oxygen is required in the carburetter for burning the carbonic oxide and producing intense heat. The amount of oxygen required in the generator for producing carbonic oxide, and the amount of oxygen required in the carburetter for complete combustion can be determined from the amount of carbon that is contained in the fuel fed to the generator. If the amount of carbon is definitely known, the amount of oxygen can also be known, and therefore, we can definitely determine the amount or weight of air which must be supplied to the generator in order to obtain efficient combustion of the carbon, and complete combustion of the carbonic oxide. It can, therefore, be seen that the successful and efficient operation of a gas producing plant depends largely upon the consistency of volume or rather weight of air supplied and not upon the pressure under which this air is delivered. If the fire is clean and free from clinkers, a half a pound of air pressure possibly would be sufficient to give the desired quantity of air per minute. If, however, the fire is in an unhealthy condition, owing to the formation of a blanket of clinkers over the grate, a higher pressure to blast the same quantity of air per minute through the fire is required. Therefore, any device which will control the air supplied in such a manner as to deliver a constant weight of air regardless of the pressure necessary to force this air through the generator will be the most efficient device for gas making.

Fig. 5 shows a diagrammatic arrangement of a constant volume governor. This governor is placed on the intake end of the compressor. The air is admitted through a conical pipe (a) into an elbow (b) direct connected to the inlet flange of the compressor. In this conical pipe is mounted

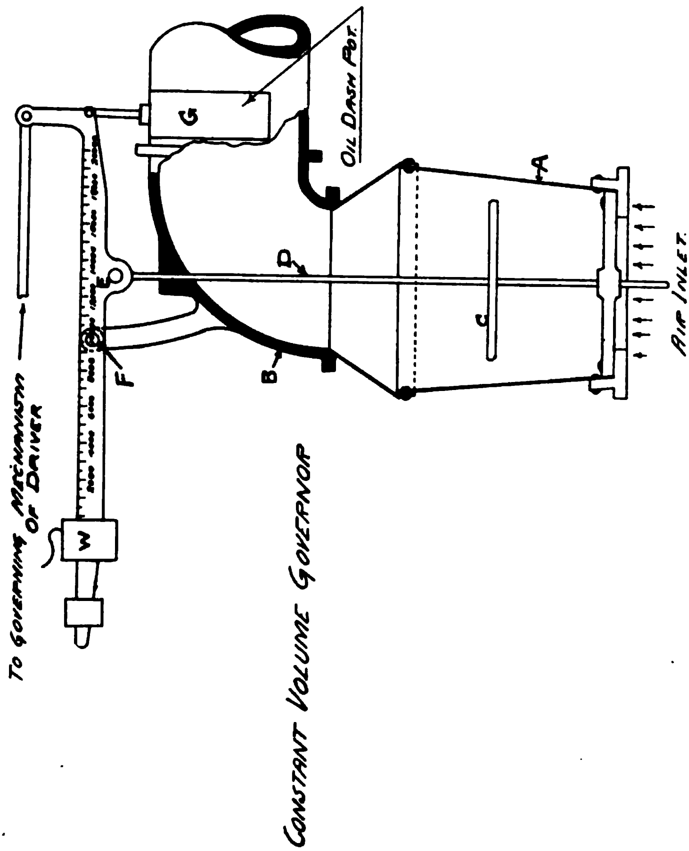


Fig. 5.

a horizontal float (c) suspended from a vertical rod (d). The latter is connected to a beam (e) which is free to move about a pin support (f). The beam is graduated to indicate the amount of air in cubic feet per minute that the compressor will deliver if the sliding weight (w) is placed at any

certain graduation. An oil dashpot (g) is attached to one end of the beam to dampen down any too violent oscillations. The method of operation of this governor when furnishing air to the gas making apparatus is as follows:

Suppose that 14,000 cubic feet of air is to be delivered to the generator and carburetter. The sliding weight (w) is set, therefore, at the graduation marked 14,000 cubic feet, and the float (c) will assume a definite position with relation to the conical pipe (a). Let us assume that 14,000 cubic feet of air is being delivered under a pressure of ¾ of a pound. If at any instance the fuel in the generator becomes more densely packed, or if the generator is slowly beginning to get into an unhealthy condition by the formation of a blanket of clinker, the resistance to air flow through the generator is increased. With this increased resistance the compressor can no longer deliver 14,000 cubic feet of air, and we may say that momentarily a less quantity is being delivered by the compressor. Just as soon as this occurs, the float (c) can no longer remain in its present position, because it is not sustained by the original volume of air passing by it. As the volume of air decreases the float (c) will start to drop in the conical pipe. Just as soon as this occurs, the rod (d) will pull the constant volume beam (e) into a new position. The end of this beam arm is connected with the governing mechanism of the driver. In the case of a steam turbine drive, it will admit more steam to the turbine and speed it up. In the case of a D. C. motor drive it will move the rheostat and increase the speed of the motor; and in the case of an A. C. electric drive, it will change the resistance of a water rheostat and thus increase the speed of the motor. Hence, no matter what form of driver is used, this governing mechanism will increase the speed of the driver so that the compressor will run at a higher speed and deliver a higher pressure. The pressure will continue to increase until it is sufficiently high to overcome the added resistances in the gas generator and thus again force the

original quantity of air through the apparatus, in this case 14,000 cubic feet of air a minute. The constant volume governor, therefore, will instantly respond to any change of condition in the gas apparatus so that if the resistance to air passage is increased, the compressor will speed up and overcome this resistance, and when the resistance is removed, the compressor will slow down again and lower its pressure, but the governor will automatically keep the volume of air supplied by the compressor absolutely constant.

The United Gas Improvement Company have recognized the necessity of supplying a constant volume of air during the process of gas making and have installed upon the discharge end of the compressor an air meter in the shape of a Venturi meter, which is to measure the amount of air flow on the discharge end of the blower. It can, however, be readily seen that this air meter will not perform the function intended because the pressure on the discharge end of the compressor will continually vary in order to deliver a constant volume. If the air meter registers the correct amount of air or oxygen supplied when the discharge pressure is ¾ of a pound it will no longer register the correct weight of air when the pressure is increased or decreased; that is, the air meter on the discharge end will only measure constant volume at various densities, hence not constant weight of air or oxygen. We know that 14,000 cubic feet of air under ¾ of a pound pressure contains less weight of oxygen than 14,000 cubic feet of air under one pound pressure. Hence, the indications of a constant volume at the discharge end of the compressor do not necessarily mean a constant weight of air or oxygen. Again this meter as installed does not automatically control the supply of a constant weight of air, but simply furnishes a means of indicating what is happening at the discharge end of the compressor and it is left to the operator to so change the speed of his blower that this volume can remain fairly constant. In all the installations that the author has been able to study it was not possible for the

operator to be continually controlling the speed of the compressor so that a constant volume could be secured. The constant volume governor as described above and illustrated in Fig. 5 is a device that has been patented by the General Electric Company and can be readily applied to their centrifugal compressors. This device is extremely simple and very sensitive, and will respond immediately to all variations of resistance in the discharge line and therefore will govern efficiently.

It may be interesting to mention before closing that this type of governing apparatus has been installed in a number of cases on centrifugal compressors for delivering air to blast furnaces. The problem of delivering air to a blast furnace is exactly similar to the problem of delivering air to a gas generator. In both cases the air supplied is used for combustion purposes; that is, a definite weight of oxygen is needed for burning the fuel. In the former method of controlling the operation of a blast furnace it was left to the skill of the furnace attendant to observe when a blast furnace was slowly changing its condition. When this occurred he called upon the engineer to speed up or speed down the air compressor so as to deliver a higher or lower air pressure. This change of air pressure was not demanded until the furnace gave visible signs of a change in its condition. By the installation of a centrifugal compressor with a constant volume governor, the constant volume governor could be set at any desired amount of air, and the governor would instantly respond to the slightest change of condition before the blast furnace operator could have observed this. The result has been that the centrifugal compressor with a constant volume governor has revolutionized blast furnace operation securing an absolutely constant supply of air no matter what the condition of the furnace; and by responding immediately to slight changes in the condition of the furnace it can keep the furnace under a more normal operating condition and thus both increase the output and its quality.

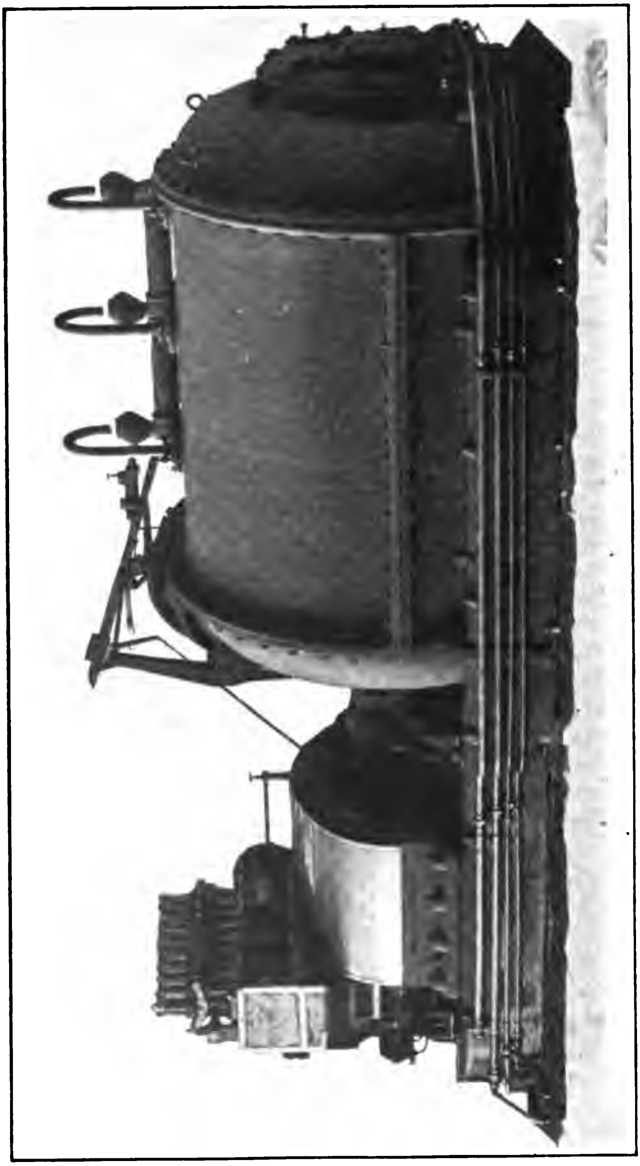


Fig. 6.

Fig. 6 is a photographic view of the latest type of multi-stage compressor for blast furnace work, and is one of three units furnished to the Iroquois Iron Company of South Chicago for delivering air to their blast furnaces. Each unit is capable of delivering 40,000 cubic feet of air a minute against a maximum pressure of 30 pounds. The normal rating of the set is 35,000 cubic feet of air per minute, and fifteen pounds pressure. The unit is direct connected to a Curtis steam turbine which delivers nearly 3,000 h-p. when the compressor is operating under normal load. The constant volume governor installed upon the air intake of this compressor is direct connected to the controlling mechanism of the turbine and will control the speed of the turbine so that the unit will deliver a constant volume of air against any pressure whatever up to the maximum pressure which the blast furnace will stand, which in this case is thirty pounds per square inch.

There is no doubt in the author's mind that as soon as a number of single stage centrifugal compressors are installed with constant volume governors in installations manufacturing water gas, we shall find the same improvement in the quantity and quality of the gas made that has been found in the quantity and quality of the iron manufactured where centrifugal compressors with constant volume governors are employed for blast furnace work.

THE CHAIRMAN: Gentlemen, you have heard Dr. Loewenstein's paper. It is now open for discussion.

MR. W. H. GARTLEY: I have been interested in what Dr. Loewenstein has said and his paper because the subject of getting sufficient blast at sufficient pressures for water gas generation is one that has not yet been satisfactorily solved.

The speaker calls attention to the fact that if Venturi meters are put on the outlets of blowers the fluctuation in pressures will introduce variables in the weight of air delivered, and this is true, but in practice he will find the percentage of error so

introduced is not very great, while in many cases the remedy he suggests is entirely impractical.

If we have, as is frequently the case, one blower supplying air to more than one machine, of course the Venturi meter at the inlet to the blower will be of no use in regulating the air to each of the machines so supplied. The solution of the problem would then appear to be to put in a separate blower on each machine, but that again introduces other serious difficulties. In blast furnaces they blow the furnace for several hours. In water gas manufacture the object is to get your blow as short as possible.

Mr. Glasgow pointed out many years ago that there was one condition of the fire most suitable for gas making, and the more we depart from that condition the less efficient the operation becomes. Consequently, in these days it is not unusual to blow three minutes, and some times even less.

Again if we have a centrifugal blowing machine supplying air to one generator in this way, we must either continue the blower at speed through the gas making period as well as the blasting period, or we must shut it down part of the time. Our experience has been, where we had a centrifugal blower operated by an electric motor and connected to a three million foot generator, *i. e.*, a separate blower to each generator, that the length of time it takes to get the blower up to speed so as to give the pressure desired was so great that if the machine was shut down during the gas making period and an attempt made to start it again during the blasting period, the full time intended for the blasting period was consumed in getting the machine to deliver the air in the required quantity and at the required pressure. In order to get the proper delivery of air at the beginning of the blasting period it practically amounted to starting the blower up from rest shortly after the machine was put on making gas, and shutting it down shortly after the blasting period commenced. This, of course, was impracticable. Running the blower throughout the gas making period was wasteful, and we eventually changed from delivering the air

to each machine from its individual blowers, to delivering the air into a header from which each machine could take its supply. This resulted in our requiring only two blowers where three were formerly used. Having the blowers operated by electric motors in this house, which contains three 3,000,000 cubic feet machines, supplied by a separate wire leading direct to the switchboard, we could see plainly the saving thus affected.

I want to ask Dr. Loewenstein two questions: first, does the apparatus make much noise? I ask this because noisy apparatus in a gas works is likely to militate against its use. Second, if you close the valve on the outlet, can the apparatus still revolve without fear of accumulating pressure and wrecking?

THE CHAIRMAN: Any further discussion?

MR. GRISWOLD: Mr. Chairman, it seems to me this difficulty in regard to water gas might be fixed up if Mr. Loewenstein would apply one of these governors to each connection to a water gas machine so connected up that it would operate a valve on that particular line. He would have to provide some other form of governor on his prime mover, to be sure that the maximum pressure necessary would be there to handle any one of the connections. If you had it fixed up in that way with an individual governor in each connection on each machine, of course you can handle any number of machines from the same header. I do not know whether it would be possible to fix up such a governor as that.

Mr. Loewenstein has referred to the matter of the Venturi meter. I have not had anything to do with the Venturi meter, but it is my impression that the Venturi meter is used to indicate the weight of fluid passing through it instead of the cubic feet.

MR. V. F. DEWEY: Mr. Chairman, there is another point I had in mind in hearing this paper presented, which Dr. Loewenstein did not touch on at all, and that is the use of the centrifugal machine in the delivery of gas. I should like to ask

him what are the particular, peculiar problems that they encounter in the handling of gas as compared with air?

I believe they have gone through this problem up at the Worcester plant, and they found some very interesting problems, due I believe to conditions in the specific gravity which you get in the delivery vanes, and of course this centrifugal motion or centrifugal action that you get varying with the specific gravity of the gas lamp.

The remark made by Mr. Gartley was what I intended to make if it had not been brought out. There is one point that he did not mention, however, that is the blowing of the water gas machine. We have two things to contend with, the amount of air put in the generator, and the amount of air put in the carburetter and this device here would of course regulate the pressure to give a constant volume to the machine, but you also have to have a device which would cut down the carburetter valve in direct ratio as the pressure was raised, which is a very serious matter in the operation of a water gas machine. As a matter of fact, I think that has been one of the weak points in machine operation.

I would like to ask another question: Would it be possible to develop a machine of the centrifugal type, such as used in cupola practice, that would deliver gas against say ten, fifteen or twenty pounds pressure, with the idea of its being used as a distributing pump in place of the ordinary rotary compressor as we now have it in a medium pressure and high pressure distribution?

CHAIRMAN: Any further discussion? Dr. Loewenstein, will you reply?

DR. LOEWENSTEIN: Gentlemen: I am glad that these questions have been raised and that I am permitted to discuss them, because it gives me the opportunity to present a more completed paper.

Referring to the points raised by the first speaker it is true that our centrifugal compressors with constant volume governor will operate best when installed separately with each par-

ticular gas generator instead of installing a large unit pumping air into a main supplying a number of gas generators. On the other hand, it is possible to govern the air from a common line, as suggested by the third speaker, but we would recommend a separate air compressor for each furnace, as this would be the most ideal arrangement.

Installing a separate compressor for each gas generator would not require as much floor space as you would naturally suppose, and if you refer to some of the photographs shown in connection with my paper you will see that the amount of floor space required is very small indeed.

As to the question of starting up and shutting down, I was given the privilege by Mr. Prichard, one of your former presidents, to inspect his gas works at Lynn, and I observed there a steam driven turbo blower which was started up from practically standstill to full speed in about eight to ten seconds. I should not hesitate to say that a turbo compressor can be started up and brought to fully speed easily within fifteen or twenty-seconds at the most. These few seconds mean nothing to an operator as it takes him much longer to open the valves to admit air to the gas generator than to start the compressor set going. The compressor can also be run at full speed with the supply of air entirely shut off, either on the suction or the discharge end. The machine will then perform no work except churning the air inside the compressor casing, and the amount of power required to keep the impeller revolving at speed with no air flow is lost in the shape of heating the air confined in the casing. It is, however, not necessary to keep the compressor running at full speed when the air supply is not needed, for, as I said before, the entire set can be started up in a very few seconds.

The compressor does not need to build up pressure when the volume of air delivered is not the normal quantity, as these machines will give practically constant pressure from O quantity of air to overload quantities. The pressure curve varies according to value something like this (indicating)—the verti-

cal line representing pressure and the horizontal line representing volume. The pressure curve is slightly lower at O quantity than at rated quantity, and again drops when the quantity becomes too excessive, but the variation in pressure as you see is very slight, and we may say that the compressor is a constant pressure machine as long as the speed remains constant.

I have noticed the operation of the Venturi air meter at this same plant in Lynn. It was installed on the discharge end of the blower and the indicating U tube was placed upon the operating platform. I asked the operator what he did with the volume indications on this U tube, and he told me that he simply looks at it but he would not have time to regulate the steam admission to his blower set so as to keep a constant volume indication on the U tube, and even if he had the time to do it I am quite sure he would not be able to do it because he could not continually keep varying the speed as quickly as the volume varies. As a matter of fact this piece of apparatus is useless as far as the operator is concerned. I noticed at the time that the volume as indicated in the U tube registered 14,000 cu. ft. of air per minute, and after a half a minute run it would drop to 8,000 and then again return to 10,000 to 14,000. On the other hand a constant volume governor properly installed will regulate every second of the time and will send a constant weight of air supply through the discharge line. The governor is quite sensitive and will regulate within a few per cent. of the rated volume.

The second speaker brought up a very interesting point as to the difference between compressing gas and compressing air. In an ordinary reciprocating compressor it makes no difference whether the compressor is compressing air or gas. The power consumed remains the same and the final pressure is practically the same if the reciprocating compressor is running at the same speed in both cases. With a centrifugal compressor this is somewhat different. The centrifugal compressor, as its name implies, produces most of its pressure

due to the action of centrifugal force, that is, it entrains air or gas in the impeller at its inner diameter and discharges it at an outer diameter, but at a higher pressure, the increase of pressure being due to the action of the centrifugal force. If the impeller is pumping air the centrifugal pressure will be higher than if the same impeller is pumping gas, just exactly the same as if a centrifugal pump were pumping water or pumping mercury. If it is pumping mercury the resultant centrifugal pressure will be much higher than if it were pumping water, that is, the centrifugal pressure is dependent upon the weight of the fluid pumped. Hence, if a certain compressor is compressing air it will deliver a certain volume against a much higher pressure than if the same compressor were compressing an equal volume of gas, but the power required to compress this air against a higher pressure will be greater than the power required to compress the gas against the lower pressure. If it is necessary, therefore, to use a compressor rated for instance 10,000 cu. ft. of air against 1 pound for compressing the same volume of gas against 1 pound, it would be necessary to add another impeller so that a final pressure of 1 pound could be reached with this latter fluid. The power required for compressing the 10,000 cu. ft. of gas to 1 pound would be the same, however, as the power required to compress 10,000 cu. ft. of air to 1 pound.

If certain specifications call for a centrifugal compressor to compress gas at a certain specific gravity, and if subsequently it was found that this specific gravity was given incorrectly, it is possible to adjust the speed of the compressor within reasonable limits to give the desired pressure. I would, however, recommend that in buying a compressor of this type the specific gravity of the gas to be compressed be accurately determined, in order that the centrifugal compressor furnished will give the required discharge pressure.

Answering the question as to whether the pressure of air should only be varied on the generator but not on the carburetter, I feel that what is required is constant volume of

air to both generator and carburetter, and not constant volume of air to generator alone. It really makes no difference if the air is introduced to the carburetter at 2 pounds pressure or at 1½ pounds pressure, or at 2½ pounds pressure, as long as the quantity of air furnished to both carburetter and generator remains constant, because a certain weight of oxygen is what is needed in both generator and carburetter.

I may mention here that it is possible to supply with the compressor a constant pressure governor instead of a constant volume governor if the customer's service so demands, the pressure governor is very easily installed, in fact we have five machines at present going through the factory of which one or two are now in test, which have constant pressure governors and will be installed for furnishing air in the making of coke. The constant pressure device, however, is so universal and probably so well known that it is not necessary to enter into its description at the present time. The constant volume governor, however, is an entirely new piece of apparatus and has been revolutionary in character, and therefore I have dwelt more upon this mechanism especially as it is applicable to the needs of a gas generator.

As to the use of centrifugal compressors for pumping gas through gas mains, or for the distribution of gas in any manner whatever, I did not think it was worth while to dwell upon this subject because it is quite obvious that the centrifugal compressor is admirably adapted to this kind of work. I have simply called your attention to the fact that the centrifugal compressor is more efficient than any other form of air or gas compressing machinery, and therefore must be more efficient when used for distributing gas through gas mains. The use of the centrifugal compressor for pumping gas, as I have said before, is so obvious that I thought it would be better to dwell chiefly upon the use of the compressor for furnishing air to gas generators rather than to the pumping of gas through mains, because the former problem is a more difficult one than the latter. In the first case constant volume

of air is required, in the latter case constant pressure is necessary. The constant volume feature is the more novel feature of the two.

The third speaker raised the point whether the Venturi meter measures weights of air or volume of air. The Venturi meter measures volume and not weight, and this is the reason that the same volume indications at various pressures or densities do not necessarily mean that it refers to the same weight of air or gas. In supplying air to a gas generator, constant weight of oxygen is required and not a constant volume with varying densities. This is the reason that a Venturi meter does not do what it is supposed to do when installed in the discharge end of a compressor.

As to the noise of the apparatus, it is rather difficult to answer this question, because it must be defined in terms of some standard of noise. We can, however, say that the centrifugal compressor is not a noisy piece of apparatus. There is no high note or shriek as would be heard if an impeller were revolving in the open air. When the impeller is enclosed in a casing and is pumping air, no high pitch note is audible.

The only other question I have not answered is the question whether in closing the discharge valve the apparatus would be wrecked. I believe that I have mentioned before that either the discharge or intake may be closed absolutely and the machine kept running at speed and no damage result, because the pressure in the casing in such a case would be slightly less than the pressure at normal rating. It is not possible to overload the casing by excess pressure. There is, however, a likelihood that when the compressor is brought up to speed with no resistance in the discharge line and with the intake and discharge wide open, the motor of the compressor may be overloaded, and if this motor is an electrical piece of apparatus there is danger of burning it out. Therefore, in starting up a compressor with no resistance load on the discharge pipe it is well to start up with the discharge

pipe tightly closed, then slightly open the discharge pipe until full load comes on the motor.

MR. GARTLEY: How is that large compressor driven?

MR. LOEWENSTEIN: It is driven with a steam turbine, as you will see by looking at the photograph. This steam turbine furnishes a maximum of 5,000 horse-power and runs up to about 3,000 revolutions per minute. This other compressor that you see there shows three water pipes coming up in the middle. That represents three diaphragms, forcing the water used for filling them at three stages, the compressor sits on three stages, the air passes through one impeller, then it goes to a second impeller through the same process and then to a third impeller, each delivering about ten pounds pressure, so that you finally have thirty pounds of pressure when the machine runs about 3,000. At fifteen pounds, of course, the machine runs at less speed, and this machine will deliver any air from one or two pounds pressure up to thirty pounds pressure, and any capacity from 5,000 up to 40,000 cubic feet a minute.

At the factory we tested these units, and we ran them at forty-five thousand cubic feet a minute, and at thirty-two pounds pressure. We had enough steam going into them to go to 45,000 cubic feet, and pressure running up to about 32 pounds, although the governor will be set later, so that the pressure cannot go above 30 pounds, as that is all that the furnace can stand.

Now this unit you see here weighs less than 100,000 pounds, and they have at Gary a steam gas engine driven centrifugal compressor at 30,000 cubic feet. In other words this unit is one-third larger than the unit at Gary. One of those units with a capacity of 50,000 cubic feet of air per minute weighs one and a half million pounds. Here is a unit that gives a delivery of one-third the volume and weighs less than ten per cent. of the gas engine driven set.

We had this unit erected in our shop on foundations not higher than three-quarters the heighth of this room, and the cost of the unit and the foundations was a trifle in excess

of the gas engine set; and the floor space, the length of this unit is, if I remember rightly, about twenty feet, the width about 12 feet, 8 inches, and the heighth of the unit is in the same proportion. That little unit would not take up anything like the length of this room, which gives a comparison of the floor space. The weight, is less than ten per cent. of the gas engine weight. As to the speed, I do not want to say we are running 30,000, we are only running about 3,000, although that speed is not considered a high average where the steam turbine is concerned. We have units running up to ten thousand and they never have gone wrong when the bearings are correct and there is proper lubrication, there is absolutely no trouble in getting high speed.

The periphery of the speed is about six hundred feet a second, and the air leaving the impeller is about the same speed as the impeller.

As to the difference between the ordinary reciprocating compressor and the ordinary fan blower, what you have in this unit is an absolutely rotating shaft, that is all there is to the rotating parts of the machine; that is, you have a shaft in two bearings with volume lubrication. With this volume of oil between the shaft and babbitt, if the shaft touches the babbitt, the babbitt burns out. In other words, there can be no wear to the babbitt, the minute it starts to wear, it is gone. We have had babbitts run without any renewal, so I should say there is absolutely no chance of that shaft touching the babbitt if you have correct lubrication, and with plenty of clearance. In other words, as I said, there is three-quarters to an inch and a quarter between the rotating impeller and the discharge vane, so there is absolutely no chance of any rubbing or wear; and we have absolutely proven this to be true with the centrifugal compressor. It is not only that there is absolutely no wear to the centrifugal compressor, there is no wear of any of the parts of the General Electric centrifugal compressor. The only thing that might wear is that if you have particles of steel going through

the machine, you might sand blast the moving parts, but they are easily removable if you have such a thing.

Now just to give you an illustration as to the various uses we are putting the centrifugal compressor to which may be of interest to you, we have one at the plant of the Standard Oil Company in New York, where they have a centrifugal compressor for cleaning gas, that does away entirely with the crow bar, and all cleaning apparatus and the entire size of the unit is such that it could be placed upon this table, and it takes the place of crow bars with the size of which you are well acquainted.

That piece of apparatus works in an extremely simple manner. The gas is taken in with a centrifugal compressor through the blades on one side, and the machine is run at such speed that the gas with those particles that they wish to clean is thrown out with centrifugal force against some discharge vane. In going out through this centrifugal force, we have water for wetting down the particles of carbon, and so on, and the gas has to return through another centrifugal compressor backwards. Second, the centrifugal compressor we will say is about half an inch smaller in diameter than the first, say the first one is two feet in diameter, the other is 19½ inches in diameter, so that the gas has to go against the centrifugal force of the second impeller, and it is only then that it forces it backwards through the centrifugal compressor where you have heavy substances such as tar and so on, and the clean gas is the only gas that can flow back against that centrifugal compressor of a little smaller diameter, so that it is a very efficient way of cleaning gas; and as I say, we have quite a number of units running, the first one being installed by the Standard Oil Company, and they simply left the scrapers and other apparatus stand aside and installed this, which is a very small unit. I think it is driven with a 20 horse-power a. c. motor, and that is all they use for cleaning gas, the gas being furnished to gas engines for feeding purposes, driving generators and so on.

I did not read the paper as I presented it here, because it is a very easy matter to read the paper as printed. I preferred to talk about it extemporaneously, and I would be very glad to answer any questions that you may ask, or take part in any discussion; and at the close, I wish to thank you gentlemen for permitting me, a non-member, to come before you and offer this paper.

A MEMBER: I think a vote of thanks ought to be tendered Dr. Loewenstein for the paper which he has been kind enough to read to us, and I so move.

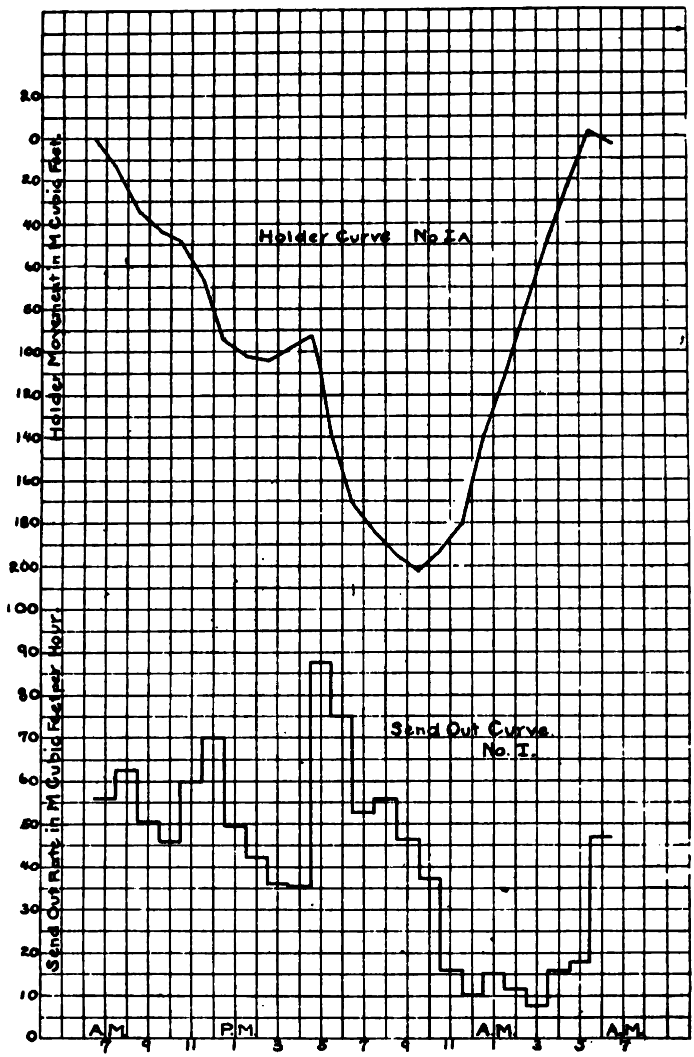
The motion was put by the chairman and was unanimously carried.

THE CHAIRMAN: The next paper is Mr. Griswold's paper on District Holders.

DISTRICT HOLDERS.

The district holder may be defined as a holder isolated from the works, for the purpose of assisting the Distribution System. They are quite common in the larger cities and they may also be found in many of the smaller cities. Some were originally works' holders and became district holders when the manufacturing plant was moved to some other location. Probably the majority were erected as district holders pure and simple.

That a district holder helps is proven by the erection of new ones from time to time. It helps just as a works' holder helps the works. With a works' holder, only enough gas making capacity to manufacture in twenty-four hours as much gas as is distributed in twenty-four hours is required. Without a works' holder, the gas-making capacity required at certain times of the day would be several times as great as when using the holder. This may be shown more clearly by reference to a gas load curve, Curve I. This curve was obtained from simultaneous readings of the station meter and holder contents at intervals of one hour for the twenty-four hours. It will be noticed that at about 6 P. M. gas was sent


Holder Curve No. I A
Send Out Curve No. I.
Holder Movement in M Cubic Feet.
Send Out Rate in M Cubic Feet per Hour.
20
0
20
40
60
80
100
120
140
160
180
200
100
90
80
70
60
50
40
30
20
10
0
A.M.
P.M.
A.M.
A.M.
7
9
11
1
3
5
7
9
11
1
3
5
7

out at the rate of 87,000 cu. ft. per hour, but the total sent out for the day was only 1,000,000 cu. ft., or an average of 42,000 per hour. With the holder, a gas-making capacity of 42,000 per hour would be ample, but, without it the capacity would have to be 87,000 cu. ft. per hour.

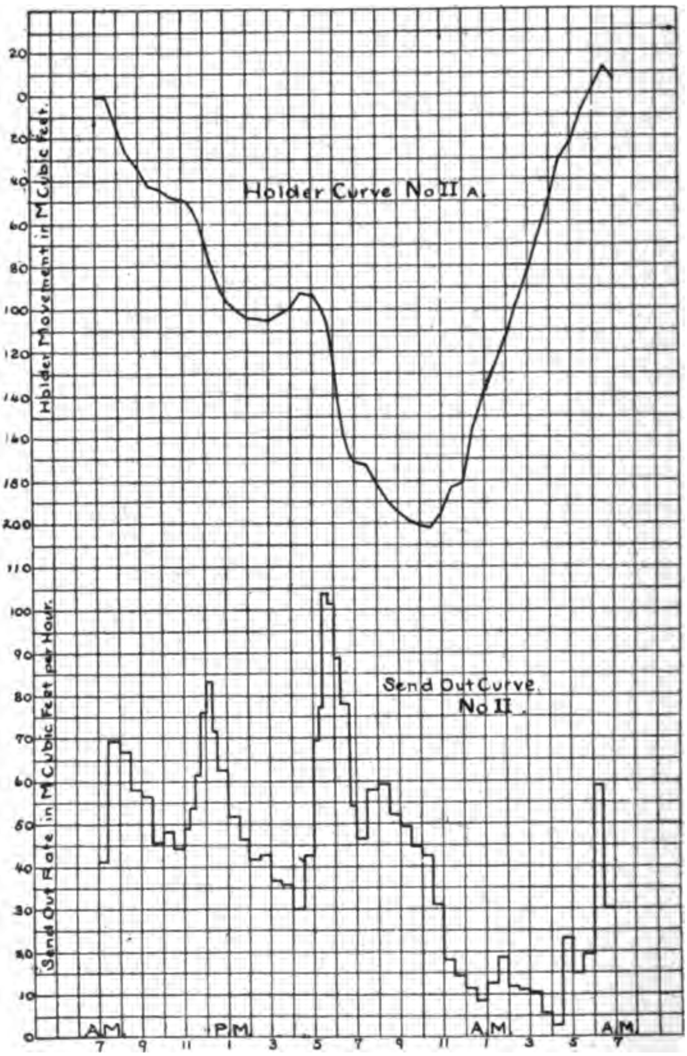
The same relation will hold true with a district holder. If a certain transmission main must deliver 1,000,000 cu. ft. of gas per day it would have to have a capacity of 87,000 per hour without a holder at the point of delivery, but only 42,000 cu. ft. per hour if the holder is provided. Many times the main is already laid and the business has increased until it is difficult to maintain good service at the peak of the load. If, now, a holder is installed at the end of this main, more than twice as much gas can be sent through in twenty-four hours and still give satisfactory service.

It will also be evident that the district holder, or storage capacity in district holders, is of just as much value to the manufacturing capacity as if located at the works. To use the illustration above, if all the gas made were sent through the transmission main before being distributed, the manufacturing capacity required would be 42,000 per hour, whether the holder was located at the works or at the discharge end of the transmission main, but in the latter case the benefit of the holder has been considerably extended.

The object of this paper is to advocate that the benefit of the holder be still further extended to include as much as possible of the distribution system. The ideal arrangement would be a holder on each service. The entire distribution and manufacturing equipment would then receive the benefit of a uniform load twenty-four hours per day. This arrangement will probably never prove practicable on account of increased investment and operating expenses. By grouping these small holders into district holders supplying areas two or three miles square, the cost is reduced so much faster than the benefits, that a considerable saving can be made by their use.

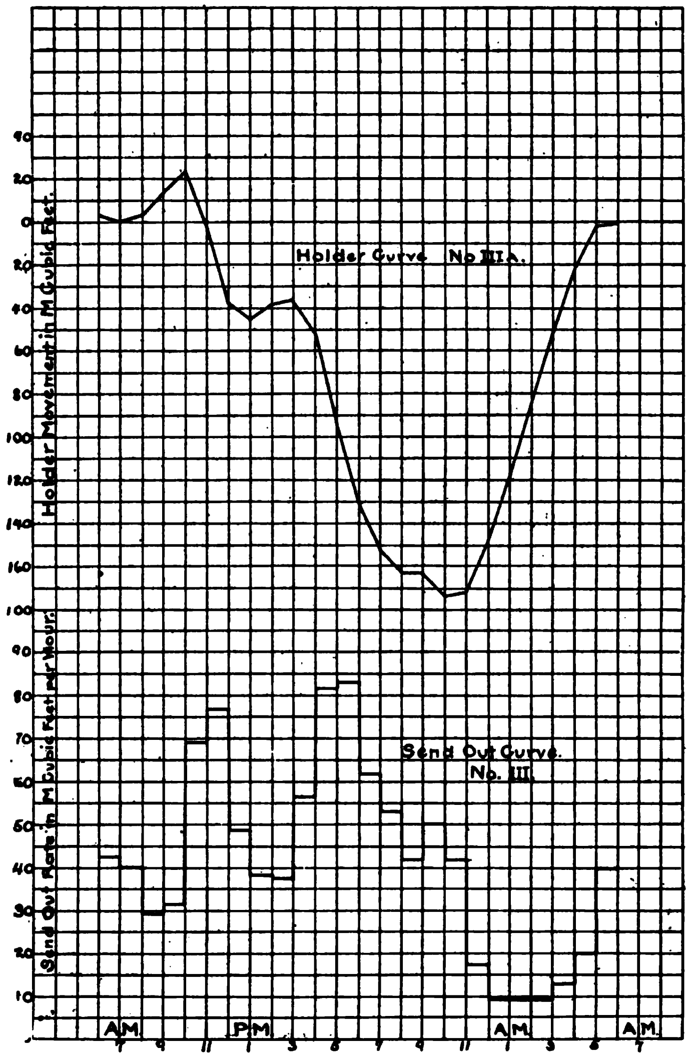
A holder on the end of an isolated transmission main increases its capacity. It would increase the capacity if the

transmission main. were "tied-in" to the existing mains at



every intersecting street and also supplied services. If this is granted, then when an outlying dstrict begins to tax a distri-

bution system, that is without a district holder, a holder should be erected within the district in question and tied into

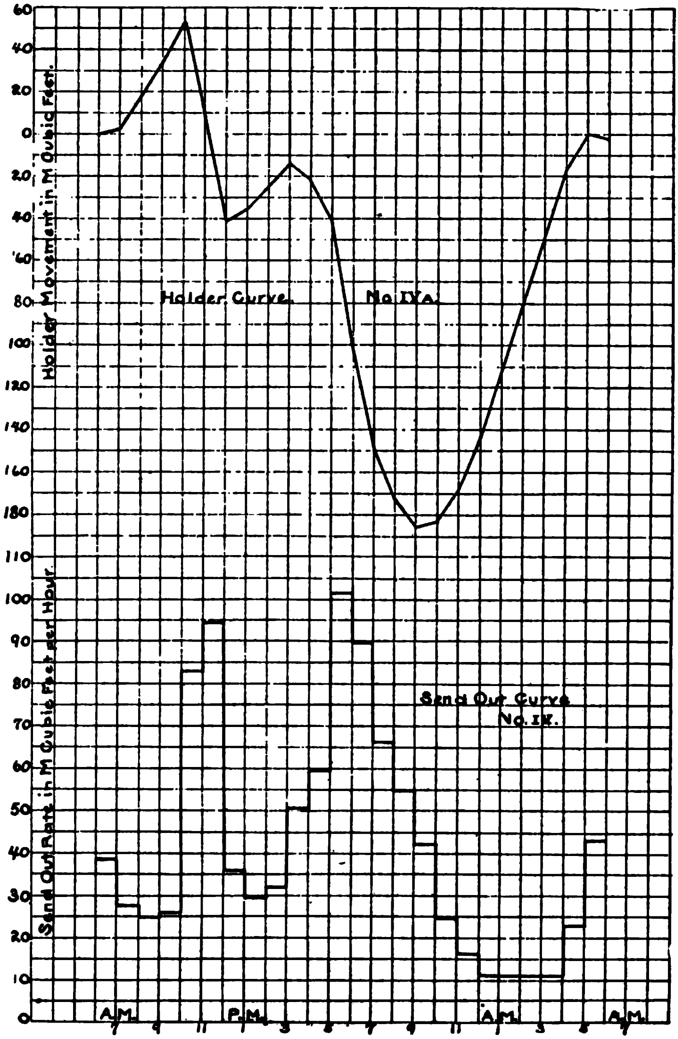


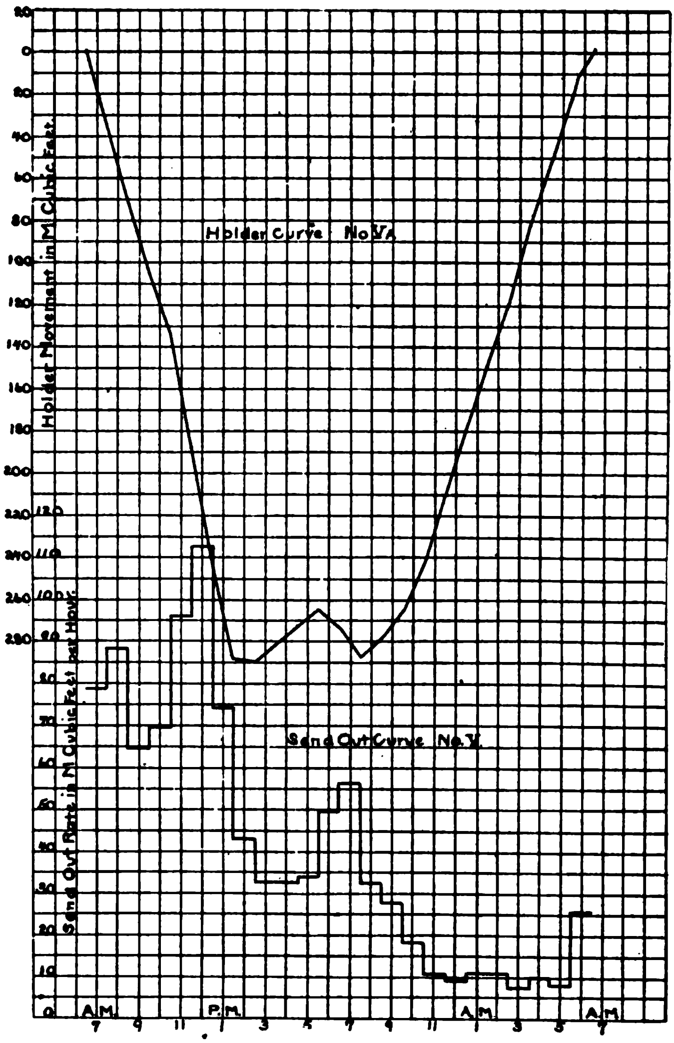
the existing mains. The existing mains would act as transmission mains between peaks feeding the holder, but during the

peak the holder would feed the mains, thereby increasing their capacity by several times. That is, this kind of district holder would be connected to the distribution mains just like strictly offpeak industrial fuel business, which we would be glad to get at say, 50 cents per thousand. During the peak, the holder will supply this gas at $1.00 per thousand to consumers, that otherwise we could not handle with the existing mains. The economy of such a transaction is evident.

In order to study the possible economies of district holders on the distribution network, the size of holder becomes of importance. There is a variety of opinion as to the holder capacity required for a given sendout. Some plants have a holder capacity equal to the maximum day's sendout, or more, and yet we can all probably recall plants that did not have a holder capacity more than 30 per cent. of the day's sendout, and yet the service was not impaired. I know of two plants that had no trouble, beyond a little extra vigilance, in giving satisfactory service with a holder capacity of 30 per cent. and 25 per cent. of the daily sendout.

In order to study this a little more thoroughly, the accompanying load curves have been collected. They were obtained from all over the country—the idea being to show as much variety as possible. This paper was not started soon enough to get but very few curves covering maximum peak conditions. Load curves appear to be very unusual among gas companies. The majority of these curves were not to be found in the files, but were taken when requested, which was in May. They will, however, serve to illustrate this paper. These curves are from both large and small plants and therefore have been reduced to a per million per day basis. Curves 1 and 2 are from the same data. The intervals in No. 1 are one hour, but in No. 2 they are only fifteen minutes during the peaks, and half hours during the balance of the day. No. 2 is introduced to emphasize the advantage of frequent readings. The takings of readings at least every fifteen minutes is strongly recommended. No. 6 has thirty minute readings over the peaks. but the balance are at one hour intervals.


Holder Movement in M Cubic Feet.
Holder Curve.
No. IV A.
Send Out Rate in M Cubic Feet per Hour.
Send Out Curve
No. IV.
60
40
20
0
20
40
60
80
100
120
140
160
180
110
100
90
80
70
60
50
40
30
20
10
0
A.M.
P.M.
A.M.
A.M.
7
9
11
1
3
5
7
9
11
1
3
5
7

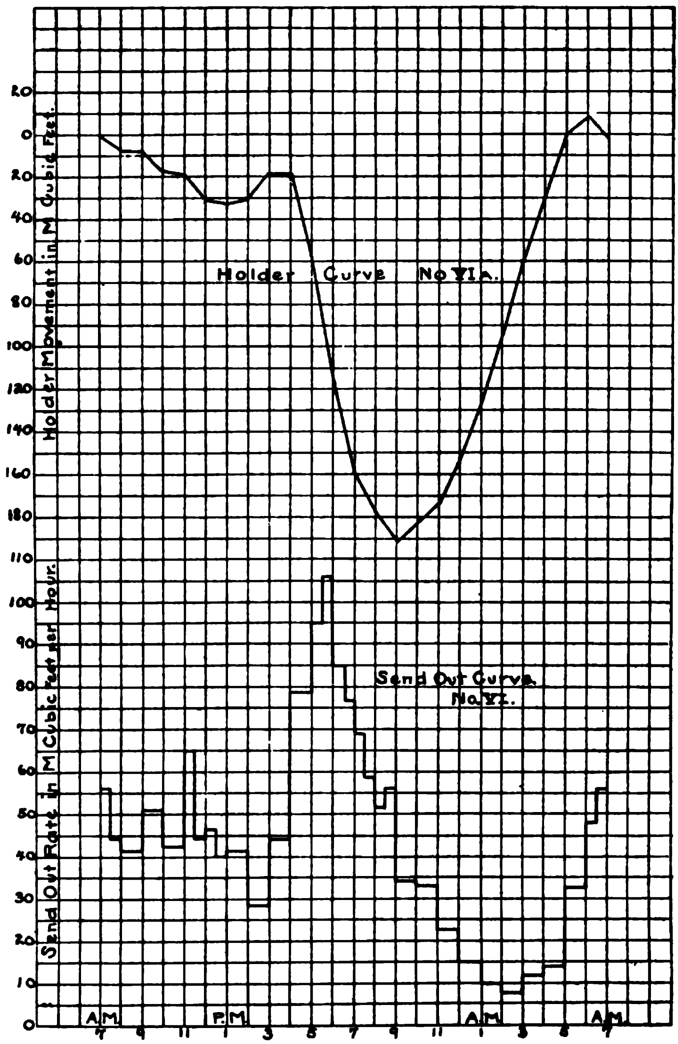

Holder Movement in M Cubic Feet
Send Out Rate in M Cubic Feet per Hour
Holder Curve No. V A
Send Out Curve No. V
A.M.
P.M.
A.M.
A.M.
7
9
11
1
3
5
7
9
11
1
3
5
7

Since all these curves represent 1,000,000 sendout per day the average is a little less than 42,000, per hour. When the actual sendout for any hour is less than 42,000 gas can be put into the holders by an amount equal to the difference between the actual sendout and the average. On the other hand, if more than 42,000 is sent out, the holder will fall, to make up the difference between the actual sendout and 42,000. By adding the cubic feet put into the holders and deducting the cubic feet drawn out, interval by interval, the curves marked sub. "a," were obtained corresponding to the several load curves. The total rise and fall of the holders for curve No. 1 is thus, 203,000, or 20⅓ per cent. of the day's sendout. This is all the holder capacity utilized. Any greater holder capacity may be useful to the manufacturing plant, as an insurance against lack of gas due to breakdowns, etc., but will not be utilized ordinarily.

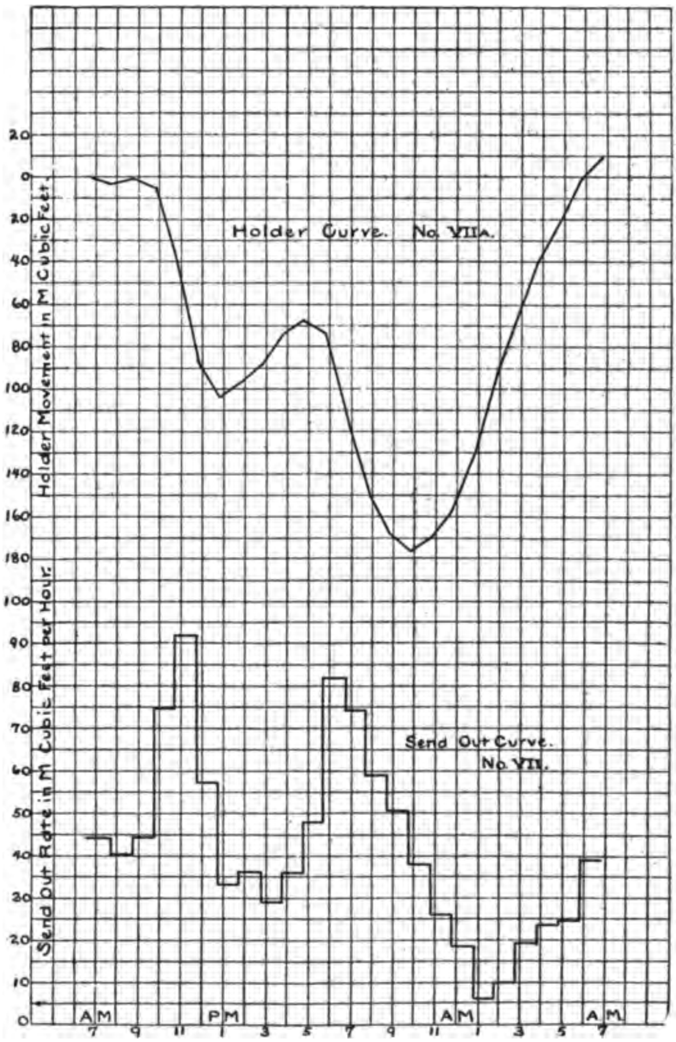
Let us call that part of the total holder capacity actually used (*e.g.*, 203,000 in the example above) the "active" holder capacity and the balance the "reserve" holder capacity. The "active" capacity varies from month to month and even from day to day. Curves 3 and 4 are for the same plant, taken in November and February, respectively. Curves 12 and 13 are for the same plant and both taken in December. As the "active" holder capacity changes, the "reserve" capacity is, of course, affected. The natural growth of the business also encroaches on the "reserve" capacity, until sometimes very little is left. as noted above.

The subject of "reserve" capacity is not within the province of this paper. It concerns manufacturing equipment entirely.

Statistics are not at hand, but undoubtedly, 99 per cent. of the money invested in the distribution of artificial gas in the United States, excluding services and meters, is invested between the holders and the consumer's premises. Even in plants using district holders at the terminus of transmission mains, at least 95 per cent. of the investment will be between the holder and the services, and not over 5 per cent. between the holder and the works. Furthermore, this 5 per cent. be-



tween the holder and the works never proves so unreliable as to justify any "reserve" capacity. The maintaining of "reserve" capacity in excess of the "active" capacity may be necessary to protect manufacture, but is not necessary and is



not used in connection with distribution. Of course, in selecting a district holder, we would not select or demand one just large enough for the immediate "active" demands, but would look forward and select some commercial standard size,

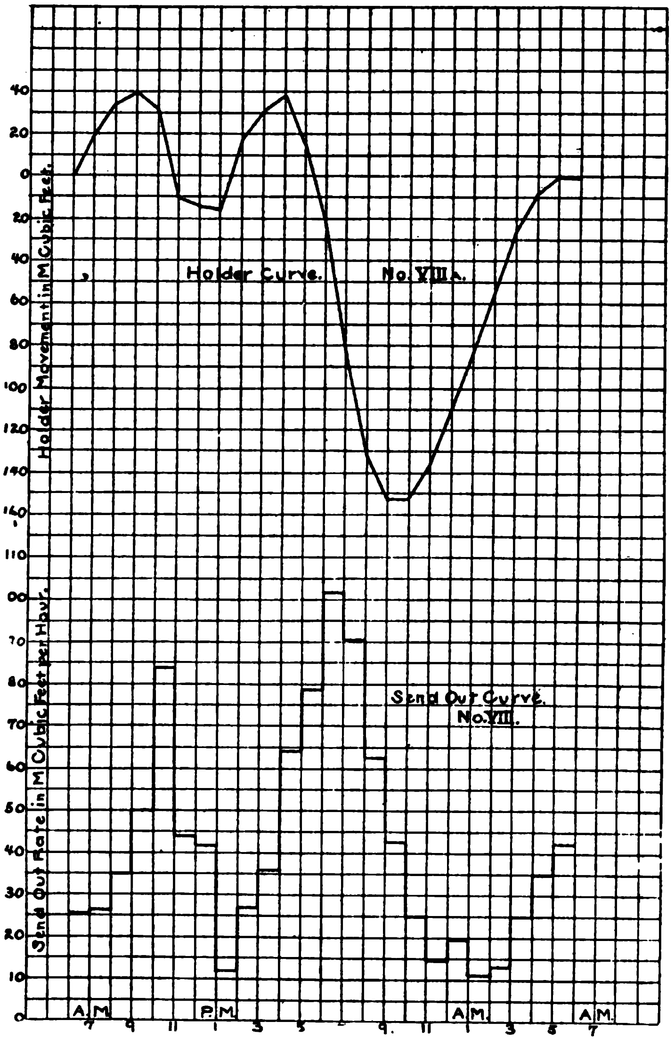
with the expectation that in a few years the entire capacity will become active. We do the same with mains, but no one would attempt to maintain his mains at all times any larger than called for by the demand.

To return to the study of the load curves and the "active" capacity required, we note that the demand varies from 83,000, or 8.3 per cent. of the day's sendout, to 116,000, or 11.6 per cent., and the "active" capacity also varies.

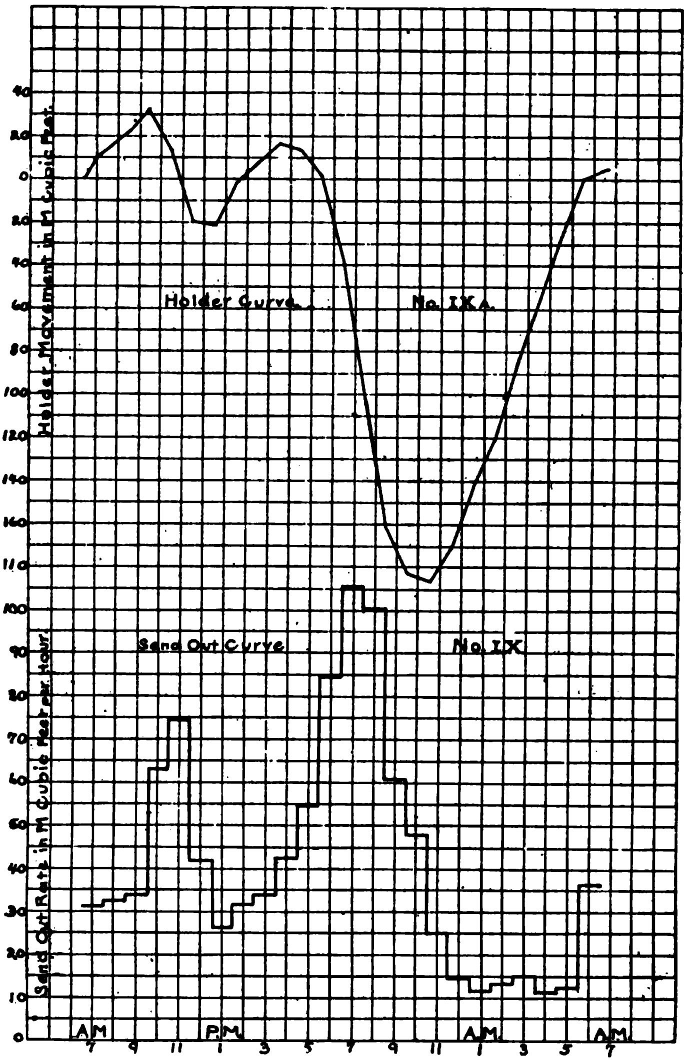
The following table shows the peak demands, in cubic feet per hour, and "active" holder capacity required in per cent., of the days' sendout.

Curve	Peak cu. ft. per hr.	Active storage % of sendout
1.	87,000	20.3
2.	103,000	20.3
3.	83,000	19.3
4.	102.000	23.7
5.	113,000	29.4
6.	106,000	19.9
7.	91,000	17.3
8.	102,000	19.2
9.	106,000	22.0
10.	91,000	21.4
11.	103,000	23.3
12.	101,000	22.3
13.	116,000	23.6
14.	102,000	27.5

First, comparing curves with about the same demand, we find that No. 8 and No. 14 have a demand of 102,000, but the holder capacity required by No. 8 is 19.2 per cent. and by No. 14 is 27.5 per cent. This indicates that whereas the sendout and therefore the revenue is the same, and the peak demand, and therefore, the mains are just the same, No. 14 requires 43 per cent. more active storage capacity than No. 8. Number 3, 6 and 8 have practically the same requirement in storage, but No. 6 and No. 8 have demands about 25 per cent. greater than No. 3.

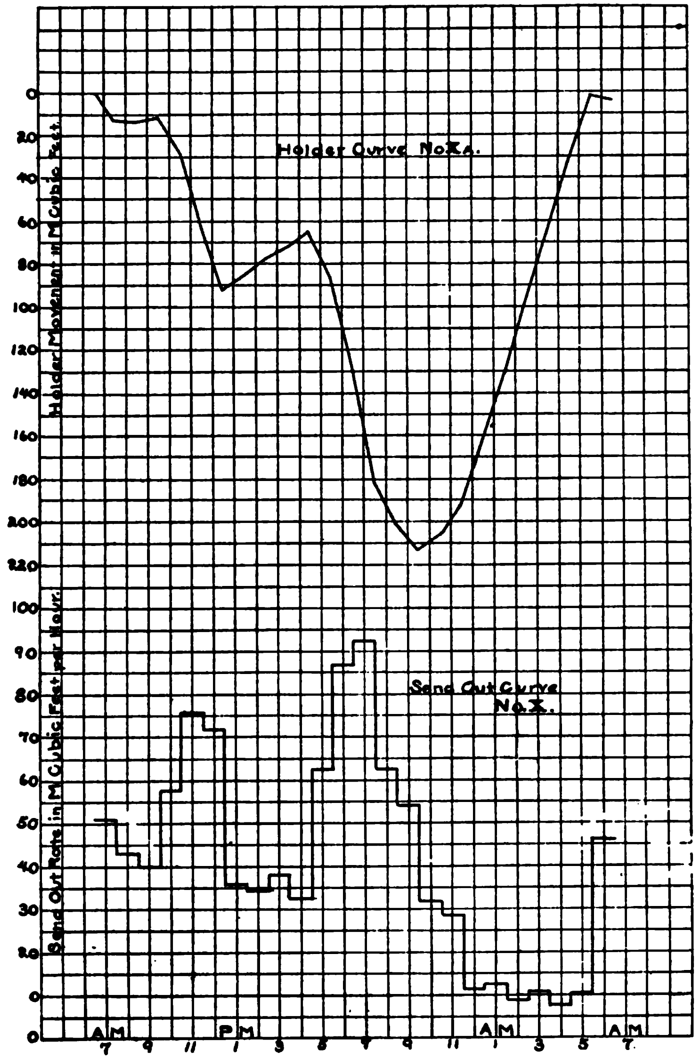


These are mostly isolated curves reduced to a common basis for comparison. To deal intelligently with a given case will require many curves covering the whole year, so as to determine with certainty the maximum demand and the maxi-

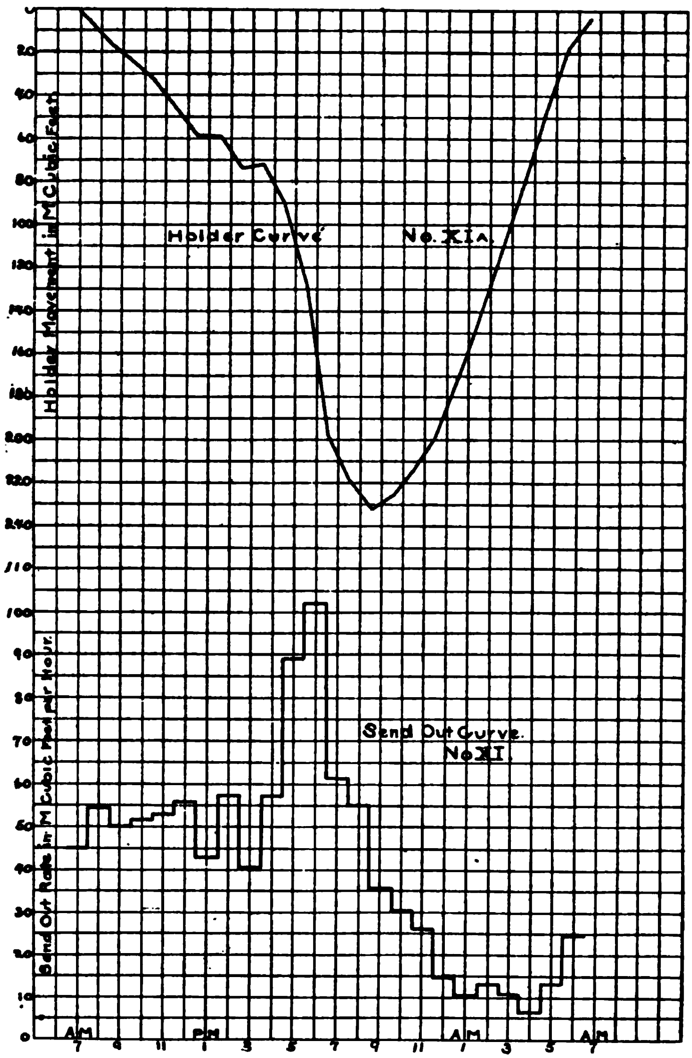


mum storage in actual figures. For, example for curves No. 12 and No. 13, the actual data is as follows:

	Date	Sendout	Peak demand	Storage used
No. 12	Dec. 24″	4,216 M	426,000 per hr.	940,000
No. 13	Dec. 19″	3,975 M	461,000 per hr.	934,000

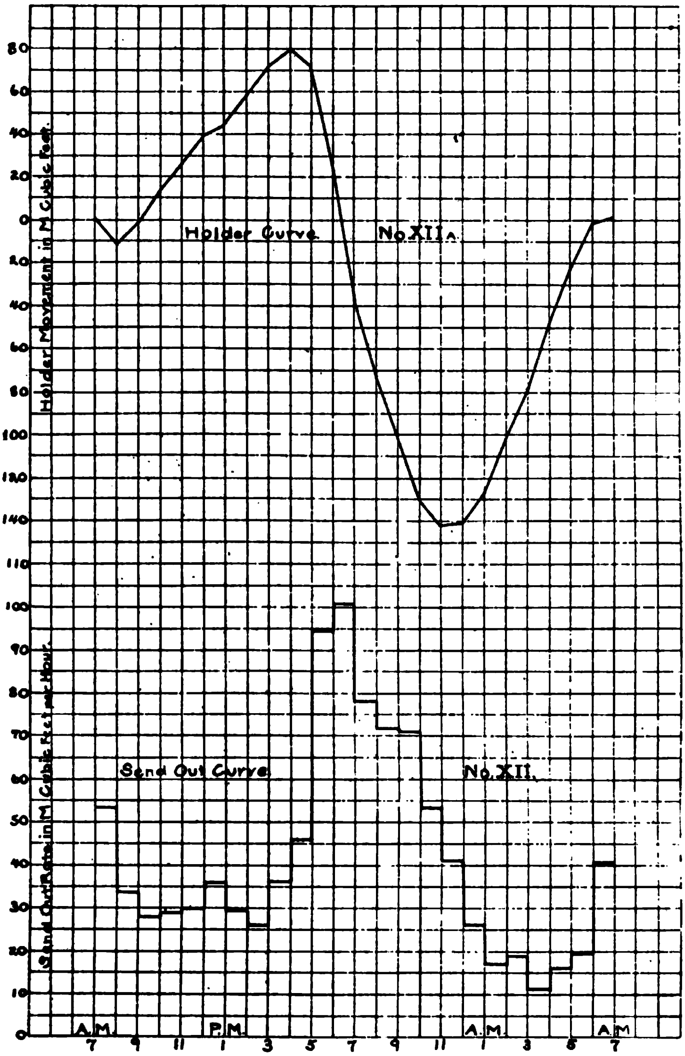


You will note that the maximum demand does not follow the sendout nor the active storage. If we all had the curves for this month we would probably find the maximum sendout

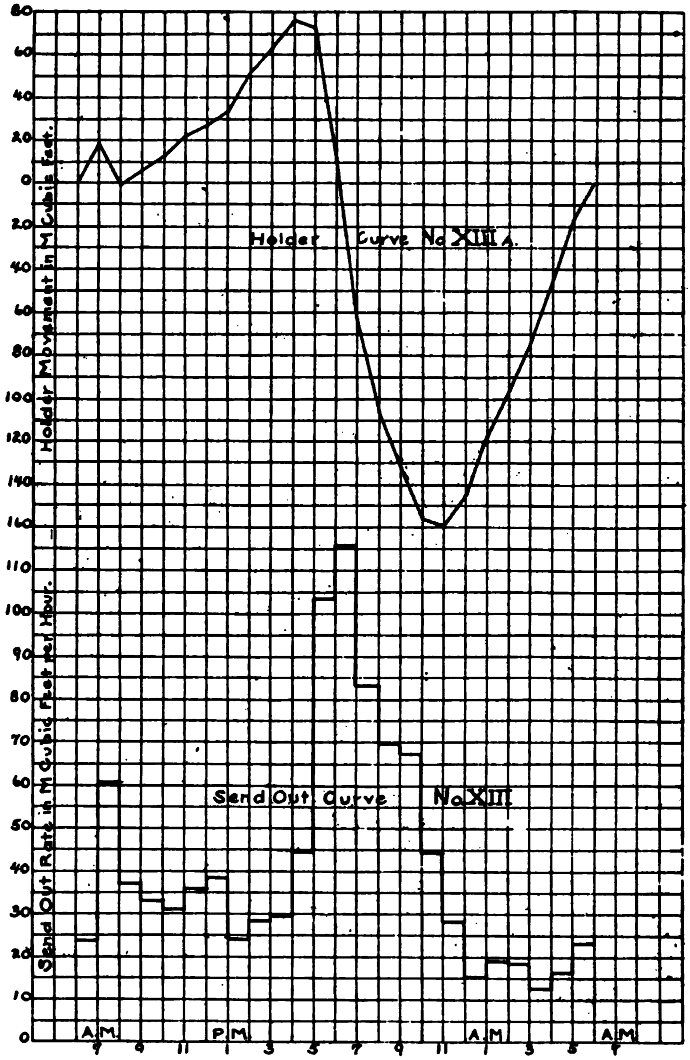


on one day—the maximum demand on another day and the maximum storage used on a third day.

A district holder such as advocated in this paper has been in use in Denver for two years. Curve No. 15 may, therefore,

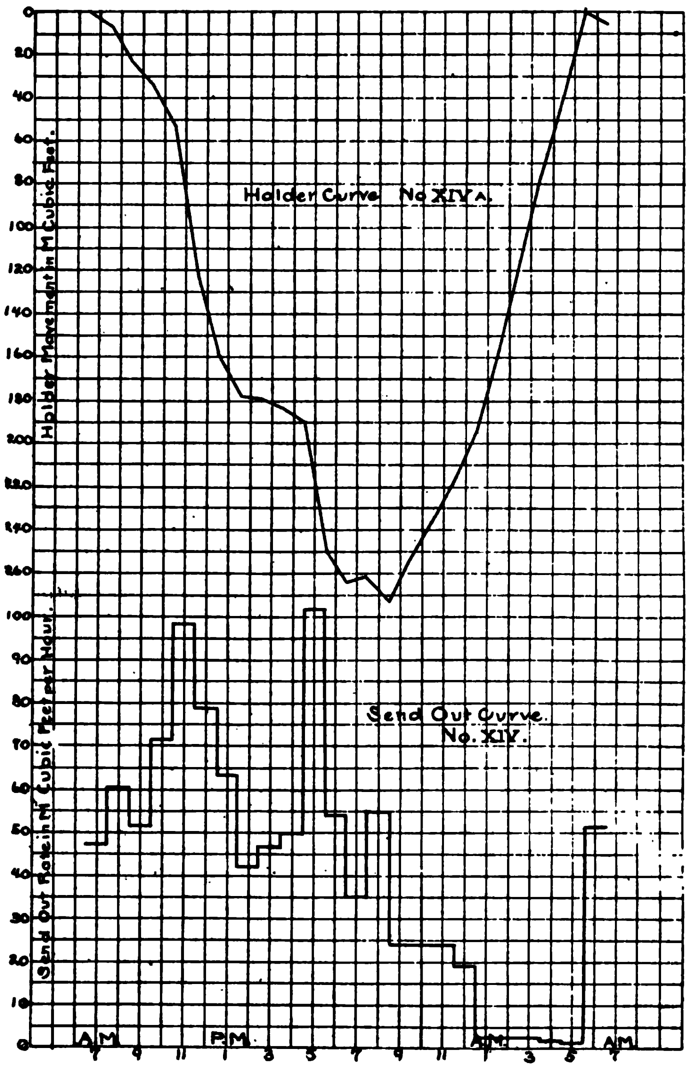


be of interest. The solid curve shows the total sendout, just as it would be without the district holder. The broken curve shows the sendout from the works alone. The difference between these two curves shows the rate at which gas was put

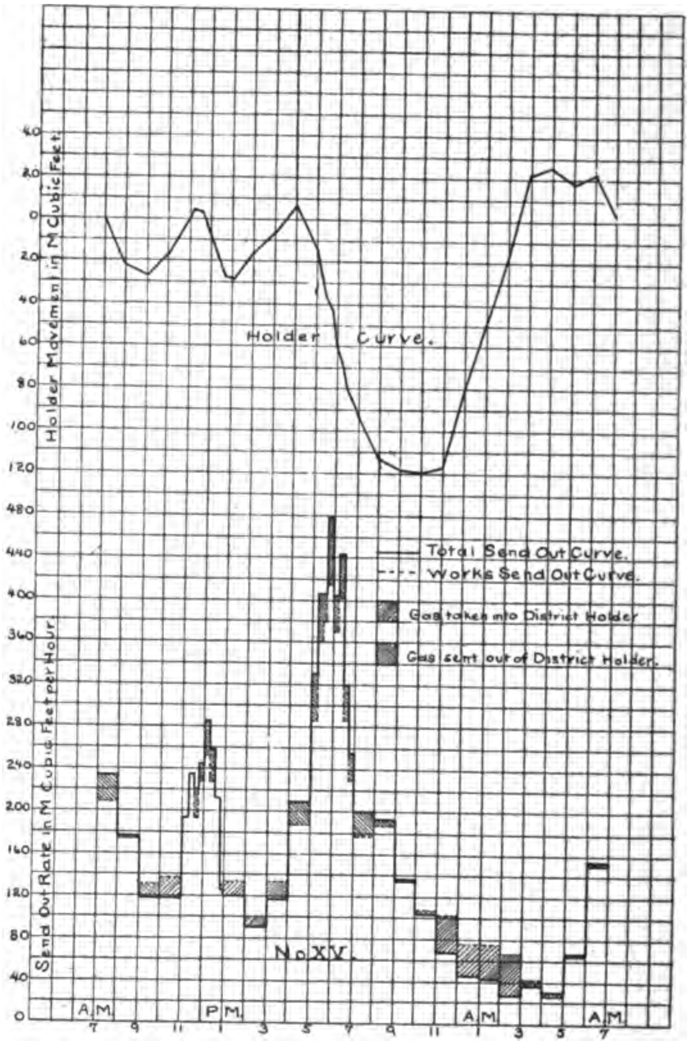


into or drawn from the district holder. Curve 15a shows the amount of 'active" district holder storage to effect this result.

The full value of a district holder cannot be judged from .



these curves because this holder is attached to only one branch of the distribution system, the other three branches handling about two-thirds of the total gas. However, the peak demand has been depressed about 14 per cent. The amount of


Holder Movement in M Cubic Feet.
Holder Curve.
Total Send Out Curve.
Works Send Out Curve.
Gas taken into District Holder
Gas sent out of District Holder.
Send Out Rate in M Cubic Feet per Hour.
No XV.
A.M.
P.M.
A.M.
A.M.

active capacity in the district holder to accomplish this result was 4 per cent. of the day's sendout and 25 per cent. of the total active storage.

This method of using district holders does not require any additional holder capacity, but rather a division of the holder capacity into holders of suitable size and so located and connected to the network that the benefit of the total storage is made to apply as nearly all of the distribution system as possible. In such a system of holders one will be necessary near or at the works and may be included in the works' holder, with whatever "reserve" storage it seems necessary to maintain. The same storage capacity which would become "active" if all storage were at works, would still be ample, if a portion was distributed as district holders. This feature should not be lost sight of. If additional storage must be provided, either "active" or "reserve," the possibility of distributing this additional storage about the distribution network and so increasing its usefulness about 100 per cent. should certainly be looked into.

The conditions that particularly favor district holders are:

1. High peak demands. This means there is room for much saving in distribution capacity.
2. The more valuable that portion of the distribution system that can be placed between the holder and the works, the greater the advantage of a district holder. This means long and expensive mains will be given the benefit of a more uniform load curve.
3. When additional storage becomes necessary to provide for "active" storage needs. In this case, the storage must be provided anyway, and it is only a question of its location. The amount of "active" storage necessary to handle the load curve—whether large or small has nothing to do with this condition, except in determining the needs of each holder location, so that storage will not be wasted by being too large, or benefit lost by being too small.

Conditions 1 and 2 make district holders possible. Condition 3 may have no weight, because although the plant will in time grow to any reasonable storage capacity, it may take so long that the interest on premature storage investment may amount to more than the value of the holder.

No specific pressures have been considered in preparing this paper as the principle is applicable to any pressure system.

THE CHAIRMAN: Gentlemen, the paper is open to discussion. I would like the discussion to be as brisk as possible. We have another paper, and we haven't very much time between the passing of this meeting and the opening of Dr. Bone's lecture, so I would like the discussion to start at once. Mr. Forstall, will you start it?

MR. WALTON FORSTALL: I have not very much to say, and what I say is with diffidence, because I am not a manufacturing man. Mr. Griswold makes this statement on page 432:

"In order to study the possible economies of district holders on the distribution network, the size of holder becomes of importance. There is a variety of opinion as to the holder capacity required for a given send-out. Some plants have a holder capacity equal to the maximum day's send-out, or more, and yet, we can all probably recall plants that did not have a holder capacity more than thirty per cent. of the day's send-out, and still the service was not impaired. I know of two plants that had no trouble, beyond a little extra vigilance in giving satisfactory service with a holder capacity of 30 per cent. and 25 per cent. of the daily send-out."

Personally, I believe that nothing except a temporary inability of the company to build a holder would excuse a condition of that kind, and I would be interested in hearing of the pressure conditions in those towns. As I said before, I speak with diffidence because I am not a manufacturing man, but I do not want the statement to go on record without some opposing comment.

THE CHAIRMAN: Any further discussion? If there is no further discussion, Mr. Griswold, will you reply?

MR. R. G. GRISWOLD: I would like to say in regard to this thirty per cent. of the send-out in storage capacity, I introduced that only to show that as far as the distribution systems are concerned this thirty per cent. was ample to handle the variation in the load. No, I do not think myself that it was perhaps safe to run with so little storage, because if anything had happened we would have been down; but as far as the distribution system is concerned that storage capacity was ample. It was possible to maintain just the same pressure with that small amount of storage.

THE CHAIRMAN: We will now have Mr. Whittaker's paper.

TAR AND TAR PRODUCTS.

Tar as a by-product has been accorded but little attention at the hands of the American Gas Institute and of its predecessor, the American Gas Light Association. From the first meeting of the old Association in 1873 down to the present meeting of the Institute, as far as I have been able to find by looking over the proceedings, there have been only two papers presented that in any way treated of the possibilities of tar as a source of revenue. One paper was on the "Manipulation of Water Gas Tar" by Mr. David Douglas in 1891, and the other by Messrs. Little and Skinner in 1909 on "Tar as Applied to the Surface Treatment of Roads."

There have been, of course a number of papers on the recovery of tar and on its uses as fuel, and in generators, but no papers, with the exceptions noted, that took cognizance of its commercial values and the processes that make it valuable.

The object of this paper is to submit to the members of the American Gas Institute, a report of the business in tar and tar products carried on by the Atlanta Gas Light Company for the last two years. The results obtained have been considered by a number of our friends, sufficiently noteworthy to bring before you gentlemen. We have, however, no intention of exploiting our achievements as such, but rather of carrying out the idea expressed in our constitution of "a friendly inter-

change of information and ideas" that might lead some of you to view tar in a new light.

Tar has been the necessary accompaniment in the production of illuminating gas since Murdock started his first gas works in 1798.

The early promotors of the gas business were probably handicapped in their first efforts by the presence of tar and they resented the appearance of this unwelcome offspring. Tar was a decided nuisance. When a nuisance is worked up

Photo 1. –End view of creosoting tank showing railroad ties ready for removal. This tank is 6 feet in diameter, 51 feet long—306 ties, 6″ × 8″ × 7½′ make a charge and about 1,000 gallons of creosote is absorbed. One charge is to run off each 24 hours.

and has a market value then it assumes the more pretentious title of by-product.

Just as some of the early forms of gas works architecture persist in this day,—so some of the early antipathy against tar, and lack of interest in it prevail even now. To some it is a by-product, to many a nuisance, and within recent years tons of it has been allowed to flow into rivers and bays to be lost absolutely to the gas companies and incidentally to damage the fishing and to smear yachts and other craft.

Only a few years ago a change of management in a gas company only 30 miles from one of the largest cities in this country, brought out the fact that it had been the custom to pay a man to cart away the tar and burn it in an open field. Here certainly the value of tar was not recognized even under the spur of metropolitan surroundings.

In the early days of the gas industry not much attention was paid to tar. It was used as a paint and as fuel etc. In 1815 it was distilled to a certain extent, but in 1838 its use was broadened by the invention of the process for treating timber with the oils distilled.

Great impetus was given tar distilling in 1856 by the dis-

Photo 2.—Tank wagon containing 570 gallons of hot tar binder.

covery of producing aniline colors from benzol. Apparently, however, the demand for tar was not heavy enough to keep its price much above its value as fuel and this condition did not improve with the advent of by-product coke ovens in 1894 in this country. The increasing use of water gas tended to keep down the production of gas tar.

In the meantime the tar market was getting largely in the control of several large concerns that operated big plants in

different parts of the country and made pitch, roofing materials, creosote, and later on, paving materials.

In 1908 the conditions surrounding our tar business in Atlanta were not at all unusual. Our largest sales were of crude tar to a local roofing concern that distilled tar and made pitch etc. They bought tar from other gas works also.

They complained of too much free carbon in our tar and that their stills were being injured thereby and that the resulting pitch was inferior.

We had our tar stored in an old holder tank and we gave the roofing company the heavy coal tar. This tar contained 25 per cent. free carbon and naturally the pitch was not up to requirements.

Our sales fell off and tar business seemed to be at a standstill. The total sales for that year, 1908, amounted to $1425.00 and we gained 350,000 gallons in stock during the year, giving us a total stock on hand at the beginning of 1909 of 568,000 gallons. A large portion of this tar was stored in the water gas relief holder tank.

The year of 1909 was the critical one in our tar history. Our stock was increasing continuously. Our sales were small. We had, of course, tar storage capacity for several years to come in our holder tanks, and we decided to fall back on this if necessary, rather than accept any of the offers made by the large tar interests for our entire output at what seemed to us too low a price.

We felt that there was a better future for our tar than a three year contract at a low price. These long term contracts tend to cheapen tar in one's estimation and they certainly discourage experimenting.

We proceeded to boom tar for settling the dust on street surfaces and equipped ourselves with a tank wagon and sold 39,000 gallons in this way during the early summer with satisfactory results.

Later on we decided to erect a still and see what we could do with our tar ourselves.

I will describe the still later on. We managed to operate

the still in a fairly satisfactory manner and we at once found an outlet for our product by supplying road tar binder for a county road being built about 8 miles from the gas works under the direction of the Office of Public Roads.

Our tar and tar product sales for 1909 amounted to $4,670.00, or over three times the sales for 1908. We gained in stock during the year 260,000 gallons.

In 1910 our business increased and we had to put in another

Photo 3.—Spreading and rolling the broken stone.

still. The sale of roofing pitch assumed considerable importance and we disposed of our creosote at good figures.

The activities of the year are indicated by the following statement of sales:

Pitch	44,727 gallons	$3,116.83
Road Binder ..	96,628 gallons	5,094.49
Crude Tar	64,462 gallons	4,553.37
Creosote	116,836 gallons	9,940.14
Shingle Stain .	2,666 gallons	972.69
	325,319 gallons	$23,682.52

The charges against the tar account for operating etc. were as follows.

Pay Rolls	$1,831.68
Salaries and Commissions	1,525.58
Advertising	1,755.78
Repairs to Plant	256.47
Equipment	1,345.95
Barrels	820.34
Shingle stain colors	511.91
Fuel etc.	832.34
	$8,880.05

Our stock of tar increased only 60,000 gallons during the year. We distilled 278,000 gallons.

During the first seven months of 1911 we have sold:

Tar	80,559 gallons	$3,520.33
Pitch	64,074 gallons	3,408.33
Dust Tar	15,035 gallons	528.02
Creosote	141,836 gallons	12,669.74
Stain	2,137 gallons	727.78
Binder	14,700 gallons	896.49
		$21,750.69

In this period we used 103,000 gallons more tar than we made and we distilled 135,200 gallons.

Our operating expenses for this period were as follows:

Pay Rolls	$1,059.75
Salaries	1,082.89
Barrels	766.74
Fuel	322.00
Advertising	103.75
Equipment	174.50
Repairs	81.76
Shingle Stain Colors	387.13
Expense	279.54
	$4,258.06

Analysis of the July pay roll shows as follows:

		Cost per gallon of tar distilled cents
Operating and Firing Stills ..	$83.46	.41
Teamsters	30.42	.15
Repairs	14.24	.07
Loading Cars and Barrels	39.87	.20
Cleaning yard etc............	17.56	.08
	185.55	.91

The average net proceeds per gallon of tar sold and tar distilled during the first seven months of 1910 was 6 cents.

Establishing a Market for Tar Products.

The results that we have shown were accomplished by a good deal of advertising and pushing sales.

Having launched into the tar business we were in the open market with our competitors. Our success with road tar binder at the very outset was most encouraging.

DeKalb County, Georgia, was about to build a road, using binder under the direct supervision of the engineer of the Office of Public Roads of the U. S. Government. Sample stretches of the road were treated with different binders, ours among them, and ours was accepted. This stamp of approval by the Government was of great advantage to us. Full credit should be given to the Office of Public Roads for the most excellent work it has carried on under the direction of Mr. L. W. Page and his assistants and by Mr. Prevost Hubbard as chemist. They have made exhaustive experiments with all kinds of road materials and binders and their reports are of great interest to makers and users of binders.

Creosote oil began to accumulate and we employed a salesman, who had had considerable experience in another tar concern. He was fitted out with an attractive sample case, showing the different oils, paints, shingle stains, etc.

We advertised in local daily papers and in the Southern Ruralist, a paper of wide circulation in the South, and we

received inquiries and some orders from Texas to Virginia.

We got up an illustrated pamphlet on road tar and copies of this have gone pretty much all over the country.

We had a representative in an automobile on the National Highway run from Atlanta to New York and also in the Good Roads Tour around Georgia.

At the Appalachain Exposition in Knoxville in 1910 we contributed a car load of binder to be used in an object lesson roadway built by Government engineers.

We put up signs on the roads built with our material stat-

Photo 4.—Applying the hot tar binder by means of a hose from heating tank.

ing, "This road was built with Road Tar Binder furnished by the Atlanta Gas Light Company." Our tank wagons have conspicuous signs over them.

Our list of articles for sale include the following:

Crude Tar at 6 cents to 10 cents per gallon in barrel lots used for tar concrete, paint, damp proofing, dipping castings, pipe dip, roof coatings, dust settling on streets, cotton tie varnish, wood preserving, dipping shingles, coating seed to prevent being disturbed by birds etc. Also water gas tar is

sold regularly to coal gas works to thin out the heavy tar in the hydraulic main.

Pitch we sell at $11.00 to $14.00 per ton, F. O. B. Atlanta. This pitch is used for roofing, paving, water proofing. We can produce any degree of hardness desired etc.

Creosote is sold for wood preserving at 15 cents per gallon in barrel lots; for shingle stain; to disinfecting works and to wood creosoting plants where railroad ties etc. are treated. We have our own tank car to handle this product.

Photo 5.—Throwing fine stone chips over tarred surface of road preparatory to rolling.

Napthalene—We have sold some of this but we generally keep it in the cresote.

Paint—We have worked up an excellent paint by cutting back pitch with light oils. We are using this paint on our gas meters. It is very quick drying. For stacks and special iron work we add 25 pounds of graphite per barrel.

We sell our shingle stains in eight colors at 37 cents per gallon. We bought a large quantity of the color paste put up in cans with our own label to be shipped with the creosote and mixed as required.

We sell shingle stain largely direct to the builders, the dealers in the first place declining to handle our creosote.

Road Tar Binder has been referred to before. We price this at 5 cents per gallon at the gas works, or 6 cents delivered in our Tank Wagons. This is handled hot in the Tank Wagons, in some cases reaching the scene of operation hot enough to be put on the road without further heating.

The importance that refined tar is bound to take in the good roads question cannot be over-estimated. Laboratory and practical tests in various parts of the country have

Photo 6.—Tar heating tank on road work.

demonstrated that prepared tar is the binder par excellence for macadamized roads. Leave out the clay and water when building a macadamized road, and apply 2 gallons of tar binder per square yard in the proper manner, and a road is produced that is smooth, hard, dustless and automobile proof. With the binder costing 5 cents per gallon at the Gas Works, the additional cost of the superb road in De-Kalb County was only 15 cents per yard over the cost of a clay bound macadamized road. The latter sort of road would soon require 15 cents worth of repairs per sq. yard.

We will never again have to burn our tar or dump it out

at sea as long as there are hundreds of thousands of miles of road in this broad land of ours that need improvement. The price that we have set for binder, 5 cents, is rather low. We deliver in Tank Wagons six miles away for 6 cents. The large oil companies charge 8 or 9 cents per gallon delivered at the same place.

Fulton County, in which Atlanta is located, is building 4 miles of road south of Atlanta towards College Park. The first two miles was assigned to the Indian Refining Company; the next mile to the Standard Oil Company; and the next

Photo 7.—Traction engine and train of dumping stone wagons.

to the Atlanta Gas Light Company. The work is nearly completed, and the results with the different binders will be clearly seen as all the sections will be subject to the same traffic. This order called for 34,000 gallons of our binder. We have another order that we are now filling, requiring about 132,000 gallons of binder. This drive leads from one of Atlanta's best suburban sections to the Club House and Golf Links of the Atlanta Athletic Club at East Lake. This drive will become a most popular automobile course and our material will be subject to a fine test.

Production of Tar in Atlanta.

In 1909 the Atlanta Gas Works made 700,000,000 feet of gas of which 58 per cent. was coal gas; in 1910, 790,000,000 feet of gas of which 48 per cent. was coal gas. During the first seven months of 1911, coal gas was 38 per cent.. The balance of the gas, of course, is carburetted water gas containing about 3.6 gallons of gas oil per 1,000 feet. We figure our tar at 12 gallons per ton of coal carbonized and 10 per cent. of the oil used in water gas. We burn the refuse pitch and heavy

Photo 8.—View on East Lake Drive. Paved with Atlanta Gas Light Co's. road tar binder.

tar from our hydraulic main under the boilers, and charge off a certain amount of tar on account of this. Carefully gauging our holder tanks where the tar is stored, verifies our estimate of tar made. We credit manufacturing with all tar put into stock at 2 3/8 cents per gallon. The total credit per 1,000 feet of mixed gas due to tar, after deducting all expenses and crediting at 2 3/8 cents per gallon all tar put into stock was:—

1909	$12,045.52	1.7 cents per 1,000 ft.
1910	$19,607.10	1.8 cents per 1,000 ft.
1911	$14,015.28	3.0 cents per 1,000 ft.

If all the tar made had been stored at 2 3/8 cents per gallon, the credit per 1,000 feet would have been 1.03 cents in 1910 and 0.98 cent in 1911.

Quality of Tar.

The coal tar contains about 10 per cent. of water, and 25 per cent. of free carbon. The water gas tar runs very low in water. Some tests show no water at all; free carbon runs about 4 per cent. The water component is found by a laboratory distillation test. The free carbon is ascertained by the

Photo 9.—View on East Lake Drive. Paved with Atlanta Gas Light Co's. tar binder.

solubility of the tar in carbon bisulphide. A quick way to get a rough estimate of the free carbon in tar is to drop two or three drops on a piece of white blotting paper. If there is very little free carbon, under 5 per cent., the blotting paper will absorb the tar,—making a brown, oily spot with no deposit on the surface. 25 per cent. free carbon leaves a considerable cushion of carbon on the surface and the size of this cushion grades down as the free carbon decreases. The same number of drops of tar, say 3, should be used at one spot, for each test.

Description of the Tar Stills.

Our plant as it now stands, consists of four vertical stills of the German type, very similar to the one described in Lunge's book on Tar. Our stills have convex bottoms instead of concave, and two of them have domes. They are all of the same size;—7 feet in diameter by 8 feet deep,—¼ inch steel shell and ½ inch heads. They handle a charge of 1,800 gallons each. The stills are entirely encased in brickwork. A fire-brick arch spans the fire-box and protects the bottom of the still from the direct heat of the fire. The products of combustion are conveyed in flues up and around next to the shell of the still, finally escaping into the stack at a point below the tar level in the still. We have not damaged the metal of the stills in the smallest degree by the heat of the fire and caking of carbon on the bottoms of the stills has not been troublesome. Each still has a Bristol Recording Thermometer, and we are governed by this entirely in our operations. The first two stills erected have 6 inch draw off pipes connected at the center of the bottom with a 6 inch elbow. The 6 inch pipe is jacketed with fire-brick. The cock is just outside of the brickwork. This 6 inch pipe would clog occasionally. On the next two stills we therefore did away with the 6 inch pipe and substituted a trough like duct rivetted to the bottom of the still, terminating at the edge of the still with a 6 inch flange. A rod can be run from the outside direct into the bottom of the still. This facilitates cleaning out any deposits. The vapor lines run each to a separate coil in two condenser tanks. The coils consist of 150 ft. of 2 inch Pipe. Each coil is provided with a by-pass for use in case of back pressure in the coil. A 3 inch safety valve is also provided at the top of each still, and the discharge from this is piped off to a tank at a safe distance. The condenser tanks are 6 by 5 feet. The receiver for the condensed oils consists of a rectangular tank 5 by 4 by 16 feet, divided into four compartments. The light oil or the heavy oil is directed into any of the compartments as desired, and the different oils are piped

Photo 10.—Paving West Hunter Street. Atlanta Gas Light Co's. road tar binder.

off to the storage tanks. Back of the stills we have a rectangular tank 5 ft. by 7 ft. by 30 ft. divided into 3 compartments, and into this the hot pitch from the stills is run. This tank serves as a temporary receptacle for the pitch which is allowed to remain there until cooled sufficiently for barrelling. We have a furnace under each compartment for reheating the pitch should it be desirable to store it in this tank. The bottom of this tank is protected by fire-brick arches on the fireboxes. The plain still 7 ft. by 8 ft. by ¼ inch shell, ½ inch head, dome and flanges, cost us $425.00 each. Our whole plant of four stills, 1 preheating tank 8 by 8; 2 condenser tanks 6 by 5; 2 storage tanks; mason work; all piping and erecting expenses, cost $4,025.00, or about 1,000.00 per still.

Operation of Stills.

We charge the still with a combination of tars which will keep the free carbon in the pitch within the limits of the specifications. The depth of tar is gauged by test cocks. The firing must be carried on moderately until the temperature, taken at the top of the still, has reached 280 F. There is a danger of boiling over even after the 212 degree mark is passed. The water and lighter oils come over until 420 degrees is reached. Then the heavier oils begin to flow. The condenser water must be kept warm to prevent naphthalene from stopping up the oils. We run the water from 120 degrees to 180 degrees. We possibly lose some of the naphtha by not carrying a lower condenser temperature, but as we are not prepared to handle the naphtha separately we consider it of more importance to guard against naphthalene deposits. A steam pipe is connected to the vapor pipe at the inlet to the condenser. Steam is used to remove any deposit of naphthalene that might occur. A cock is placed on the main vapor line to prevent steam from entering the still, but of course this cock must be closed only after it is certain that the safety valve is ready to take care of the vapor. The line from the safety valve must also be kept clear of deposits, and a steam connection to it is essential, especially in cold weather. A tar still

must be treated with the same consideration as a steam boiler, and when it is under fire the vapor must escape easily through the proper channels, or undue pressure will be put on the still with possible disastrous results. As the final temperature is approached, a sample may be run off for testing as to viscosity, but it is rather hard to get a representative sample, and we have gauged our time of distillation by the temperature. If we were handling a perfectly homogenous tar, the quantity of oil collected would be a good index of when to

Photo 11.—Tar stills in course of erection at Atlanta Gas Works.

draw the fires, but our tar varies too much to depend on this. When the temperature determined on by previous experiments has been reached, the fire is drawn and the still allowed to cool. Jacketed as the still is with hot brick, the cooling down process is long drawn out,—and it generally requires from 8 to 12 hours before we find it safe to draw off the pitch. Our most disastrous experiences have occurred in connection with drawing off hot pitch. A dense vapor arises and several times this has ignited and set the pitch in the receiving tank on fire. It is reassuring to know that a stream of water from a fire hose will put this fire out, though the water will make the pitch

boil over out of the receiving tank. A 2 inch steam pipe with nozzles every 12 inches runs along one side of the receiving tank. The steam valve governing this is placed at a safe distance. If a fire starts the steam is turned on and literally blows the fire out. A water line is connected to the steam line, and water can be resorted to if the steam fails. This device has restored confidence among the men who were losing their nerve at the sight of lurid flames rising 20 feet amid masses of heavy black smoke in the midst of the gas works. It is our intention to provide air-tight receiving chambers for the hot pitch with vent pipes connected with top of stills. The pitch can be drawn off into these chambers and cooled in safety and the stills can therefore be run with greater frequency. We formerly would make a charge every 24 hours, in each still, but waiting for the pitch to cool has lengthened the time to 36 hours. For pitch we run the temperature to 700 degrees or 720 degrees, and for road tar to 580 degrees or 600 degrees. We usually run the road tar direct into the tank wagons at 450 degrees. Pitch has to be cooled to 300 degrees before it can be barrelled satisfactorily. For pitch we have to use heavy single headed oil barrels, the lighter barrels not proving satisfactory. We have been able to buy these barrels from 27 cents to 40 cents. Good double headed barrels for creosote cost us from 50 cents to 65 cents. Another form of receptacle for pitch is the thin iron drum, which can occasionally be obtained second hand at low prices. We use coke for fuel under the stills, a bushel of coke distilling 30 gallons of tar. Coke is charged up at 7 cents per bushel in the operating costs shown above.

Gentlemen, this is an age of conservation and economy. Conservation of national resources. Economy in all lines of manufacture. It is not conservation or economy to store your tar indefinitely, to sell it at 3 cents per gallon, to burn it under your boilers or to let it run surreptitiously into the rivers.

Even the operator of a single bench of 6's has not played

Photo 12.—Some of the tar products of the Atlanta Gas Light Co.

his proper part in conservation if a single fence post or pole has been set in the ground in his neighborhood without a coating of his tar. Trees will have to be cut down somewhere to replace the rotting fence posts. Tar will delay the coming of the axemen and the trees will grow bigger. We can adopt a new motto, "Gasman spare the tree."

The water gas operator of a junior set need not wonder what he can do with his few gallons of tar as long as the crows are eating up his neighbors freshly planted corn.

We need not worry that coke oven plants are making lots of tar; we need not fear the oil companies' by-products will destroy the tar market as long as there are thousands of dusty highways, crumbling turnpikes, and water washed Macadam pavements.

The good road movement is on. We—these United States —are spending a million dollars a day on improving roads, but it will take all the gas tar, coke oven tar, and oil products that this country can produce for a great many years before our roads are durable and dustless.

Tar is a big subject with plenty to interest the engineer, the chemist, and the salesman.

I feel that I have but touched on the subject in a general way, but if my efforts start a general discussion of this important topic, I will feel repaid.

APPENDIX.

ATLANTA GAS LIGHT COMPANY'S SPECIFICATIONS FOR MACADAM ROAD WITH REFINED TAR BINDER.

The road shall be brought to proper grade, allowing for thickness of stone work, and the soil or clay or filling shall be rolled with 10 ton (or more) steam roller, leaving the center crowned. All soft spots to be filled and rolled hard. A course of No. 1 crushed stone ranging in size from 1¼ inches to 2½ inches is laid to a depth of 5 inches, and is thoroughly

rolled. Stone screenings can be mixed with this stone for 4 inches of its depth. There should be no excess of fine material and the tops of the large stones should always be visible. No water or clay or other binder shall be used in this course.

The second course of crushed stone ranging in size from ½ inch to 1¼ inches is laid on the foundation course to the depth of 2½ inches and rolled to shape, but not too compactly. Road Tar Binder heated to about 300° F. is now applied

Photo 13.—Tank wagon for sprinkling tar on surface of streets for dust prevention.

to the surface of the stone work, preferably by means of a hose from a tank wagon—1½ gallons of tar binder per square yard of surface shall be used. Clean stone chips are next scattered over the tarred surface while still hot and immediately rolled with steam roller. The surplus screenings are swept off and a light coat of tar binder, ½ gallon per square yard, is next applied and covered with stone screenings as before and rolled.

The screenings should be left in place and any uncovered tarry spots should be covered with stone screenings.

The finished roadway may be used at once for light traffic, and in 24 hours for any sort of street traffic.

Tar binder should not be applied on wet stones nor when the temperature of the air is below 45°.

The tar binder shall have a specific gravity of not less than 1.20 nor greater than 1.27 at 77° F.

It shall be soluble in C. P. carbon bisulphide at air temperature to at least 80 per cent. and shall contain not over 20 per cent. free carbon.

When a sample of the tar is subjected to the float test, the float shall sink in water maintained at 122° F. in not less than 2½ minutes nor more than 3 minutes.

The tar shall be free from water.

THE OFFICE OF PUBLIC ROADS FURNISHES THE FOLLOWING METHODS OF EXAMINATION OF ROAD TARS.

Specific Gravity:—This method is described in detail in the *Journal of Industrial and Engineering Chemistry,* Vol. 1, No. 7, in an article entitled, "A Useful Form of Pycnometer for Determining the Specific Gravity of Semi-solid Bitumens."

Melting-Point of Tar Pitches:—The melted pitch is first poured into a ½ inch cubical mold and allowed to cool. The ½ inch cube of pitch is then fastened upon the lower arm of a No. 12 B and S wire, bent at right angles and suspended beside a thermometer in a covered glass beaker of 250 cc. capacity, which is then placed in a water-bath. The wire should be passed through the center of two opposite faces of the cube which is suspended 1 inch above the bottom of the beaker. The liquid in the outer vessel is then heated in such a manner that the thermometer registers an increase of 5° C. per minute. The temperature at which the cube touches the bottom of the beaker is taken as the melting-point.

Free Carbon:—About 2 grams of the material is weighed into a 150 cc. Erlenmeyer flask, the tare of which has been previously ascertained, and treated with 100 cc. of carbon bi-

sulphide. The flask is then loosely corked and shaken from time to time until practically all large particles have been broken up, when it is set aside over night. At the end of this time the contents of the flask are decanted off upon a weighed Gooch crucible fitted with a long fiber amphibole filter. The residue remaining in the flask is then washed with 50 cc. carbon bisulphide, allowed to settle, and decanted as before, the insoluble matter being finally brought upon the filter and washed with 100 cc. carbon bisulphide or until the washings are practically colorless. The filter and contents are then dried at 125° C., cooled and weighed. Should any residue remain in the flask, it is also dried and weighed and this weight added to that of the residue in the crucible. The per cent. of insoluble residue determined as above, minus that of any ash which may be found by ignition is reported as free carbon. Benzol may be employed as a solvent, but carbon bisulphide is usually to be preferred.

Distillation:—For this test a tubulated glass retort of 750 cc. capacity is employed. From the specific gravity of the tar, taken at 25° C., the weight of 250 cc. is calculated and this amount is poured into the tared retort. A cork stopper carrying a thermometer is then inserted in the tubulature so that the bulb is on a level with the mouth of the retort.

The tar should be heated gradually by means of a Bunsen burner and the first fraction to 110° C. caught in a graduated glass cylinder. A cold wet towel wrapped about the stem of the retort serves to condense the distillate. If the tar is a crude one containing much water, great care must be taken to prevent it from boiling over. After the first fraction is collected, however, distillation proceeds without trouble. At this point the receiver is changed for another graduated glass cylinder and an asbestos or tin cover placed over the retort for the purpose of obtaining a uniform temperature. The flame of the burner should be so regulated that about two drops of distillate per second are collected. At 170° C. the receiver is again changed and a third fraction to 270° C. collected. Distillation is then stopped and any material which may have

Photo 14.—General view of tar stills at the Atlanta Gas Works.

solidified in the stem of the retort is liquefied by the application of heat and caught in the last receiver.

If the water was present in the tar it will be noticed that the first fraction separates into two layers, the lower of ammonical liquor or water and the upper of oil, All of the fractions are cooled to 25° C., their volume percentage calculated and that of the pitch and the various distillates upon a weight basis should also be determined, and note made of the approximate volume of solids which precipitate from the distillates upon cooling to 25° C.

The results obtained from this distillation are reported as follows, to half of 1 per cent:

1. Water or ammoniacal	% by vol.———	% by wt.
2. First light oils to 110° C.....	% by vol.———	% by wt.
3. Second light oils 110° C. to 170° C.	% by vol.———	% by wt.
4. Heavy or dead oils 170° C. to 270° C.	% by vol.———	% by wt.
5. Pitch residue by difference...	% by vol.———	% by wt.
Total	100	

Directions for Making Consistency Tests With Viscosity Float—Manufactured by Howard Morse, New York.

The apparatus consists of two parts, an aluminum float or saucer, and a conical brass collar. The two parts are shown in the drawing, and are made separately for reason of economy, so that one or two of the floats will be sufficient for an indefinite number of brass collars.

In using the apparatus, the brass collar is placed upon a brass plate, the surface of which has been amalgamated, and filled with bitumen under examination, after it has been softened sufficiently by gentle heating to flow freely. The collar must be level full. As soon as the bitumen has cooled sufficiently to handle, it is placed in ice water at 5° C. for 15 min-

utes, is then attached to the float and immediately placed upon the surface of the water, which is maintained at 50° C.

As the plug of bitumen in the brass becomes warm and fluid, it is gradually forced out of the collar, and as soon as the water gains entrance to the saucer, the entire apparatus sinks to the bottom.

The time in seconds, elapsing between placing the apparatus on the water and when it sinks, is determined by a stop-watch, and is considered the consistency of the bitumen under examination. The tar prepared in accordance with directions of Office of Public Roads should show a consistency of not less than 2½ minutes and not greater than 3 minutes.

FORM 105.

ATLANTA GAS LIGHT CO.

Tar Still Operating, Daily Report

Still No._____ ATLANTA, GA.,__________ 191__

Time Charged________ Fire Started________ Fire Drawn________

Time Run Off________ Fuel Used-Kind________ Weight________

______ Ft.______ Ins. Coal Tar From________

______ Ft.______ Ins. Oil Tar From________

______ Ft.______ Ins. ________

Total Gallons Charged________

TIME	TEMP.	DEPTH OF OIL	GRAVITY OF OIL	

	Gallons	Per Cent.
Water Made		
Light Oil		
Heavy Oil		
Pitch		

Day Operator________ ________ Night Operator

THE CHAIRMAN: Gentlemen, you have heard Mr. Whittaker's paper; it is now open for discussion. Captain McKay, will you open the discussion?

CAPTAIN MCKAY: Gentlemen, I am sorry that I am unable to discuss this paper from a practical operation standpoint, but I very much appreciate the frank and full information that Mr. Whittaker has been willing to compile and to give to us.

MR. FISHER: Mr. Chairman, I would like to ask a question, on page 451 of this paper with regard to creosoting ties, he shows 306 ties taking about a thousand gallons of creosote. I would like to ask the pressure he shows in the plant, the vacuum and of what kind of wood are the ties?

MR. PERRY: My remarks will be principally on the financial side of the business. When I came to Omaha a year ago last June, we had been in the tar business for some years, doing a considerable retail business, advertising for customers and shipping tar out to them in barrels and five and ten gallon cans. We investigated our accounts and careful analysis showed that we were not making money on this business. We could sell our tar for three and a quarter cents a gallon without any distillation; and by the time we deducted all our advertising, paid the clerical hire, allowed for bookkeeping and the supervision at the works, which bookkeeping and supervision might have been given to other more important work, we figured that there was not any money in the retail trade, so we cut out all our advertising on retail tar, and took on only what came in from our previous advertising, and filled those orders.

Besides this business, we had installed a still which we could use to make roadway tar which could be used to make creosote. Now the still had been used to make but very little tar for roadway purposes, and we had to go out and drum up that business. We decided that to get that business we would make our price such as to net us three and a quarter cents a gallon, the same price we sold to the other

fellow, and we purchased two seven hundred gallon tank wagons, of the same style that the Standard Oil Company uses, so that we could spread it, and we delivered our tar hot from the still to the Park Board and County Commissioners to bind their macadam.

For 1911 we have sold approximately one hundred thousand gallons of tar for road purposes, netting us about the same amount per gallon as we now obtain from the manufacturer buying our tar.

We also make some creosote from water gas tar. Now when you want to sell creosote from water gas tar it is a difficult proposition. You are up against it; but we sold some four car loads to a creosoting firm in the North, and they liked it very much. We also sold some to stock food companies, for making sheep dip, approximately fifteen thousand gallons were sold to one company and that has proven satisfactory to them.

Now, in that business our prices which have been as much as we could obtain, were such that it nets us about three and a quarter cents a gallon, about the same that we could sell the tar for without going into this business.

When we come to pitch, when we get three and a quarter cents a gallon for tar and with pitch at only sixty cents a hundred pounds, there is nothing in the pitch business unless you can get a good price for your solvent naphthas from the dead oils. This means another still to get them out.

We have, however, sold to one firm some dead oil obtained between certain temperatures from our pitch for shingle stains. We have tried to sell our creosote for shingle stains but it is a little too dark. The dead oil from the pitch between certain temperatures seems to meet one manufacturer's demands and satisfies him and his customers. We do not make pitch unless we have room for the dead oil to supply this particular man.

Besides that, this year we sold 150,000 gallons raw tar to a certain manufacturer for three and a quarter cents per gallon.

We have brought out three principal demands, for roadway, outside sales, and our creosote business to the same basis, in competition with one another, and if it were not that we have the stills on hand I would make a contract if possible for the whole output of raw tar.

Now going back to page 455 of Mr. Whittaker's paper, down at the bottom there I notice the first eleven months for 1911 the pay roll was $1,059, salaries $1,082. The total for the expense items run up to $4,258. I find it necessary to keep one man at the works supervising the operation of the stills, and keeping in touch with the park commissioners, the county commissioners, and the road commissioners, to get their business and to see that the tar business is handled properly. Now that is at least a thousand dollars. Then there is the bookkeeping and everything else, and I should say that those items ought to be almost double what they are, that is, if you have them all in; and that would bring down your net profits considerably. I believe that anyone, before he goes into the tar business, unless he cannot get a good price for his tar, should keep out of the distillation of it and let the other fellow go in for it so long as he can induce the other fellow to pay him a good fair price, which price is perhaps fifty per cent. more than the value of tar for boiler fuel.

THE CHAIRMAN: Any further discussion?

MR. G. T. MACBETH: We have a sale of tar from our plant for road purposes, during last year we sold about one hundred thousand gallons of straight water gas tar. This year we disposed of about two hundred thousand gallons. The gravity of the tar was 1.10, and contained about twelve per cent. of oils that came over at a temperature below 475° Fahrenheit. We took no steps to get out the lighter oils or water except with the usual gas works practice of separators. This tar is pumped into an overhead tank that contains an exhaust steam coil, the tar is drawn direct from the tank to the city wagons, and they do their own spreading of this material on streets and roads.

Some of the streets show up very fine indeed; in others the results are not as good. If the traffic in residential sections is confined to horse and buggies and automobiles not running at an excessive rate of speed, it makes a very good road, and the surface is fine, just as nice as a hot tar binder road. Where the traffic is heavy and the automobiles run at high speed, on that section of the road it is of no use whatsoever. I say it is of no use, but I should rather say it is not what it ought to be; but we hope in the coming year to take some steps to extract some of the light oils, and treat the tar for work on roads and also get a little more revenue out of it than we are getting now. One man said we were almost giving it away, selling it at only two cents a gallon.

THE CHAIRMAN: Any further discussion? If not, Mr. Whittaker, will you reply?

MR. WHITTAKER: The first question asked was that about the pressure used in this creosoting plant. I suppose you are all familiar with the general process after steaming the ties thoroughly, there is a vacuum produced in the cylinder of twenty inches, and then the oil introduced and steam put in it, and they use forty pounds pressure for what they call sap pine, plain ties, sixty-five pounds pressure for heart pine, and 165 pounds pressure for oak. With the different grades they have a different pressure to drive the oil in.

Some gentlemen think there is not much advantage in distilling tar, but it makes you more independent. I would rather do it and handle the tar business ourselves than sell to the large concerns, for the general moral good of the community if for nothing else.

Referring to Mr. Macbeth's failure with the surface treatment, that is very generally true regarding surface treatment with tar. If you can possibly get refined tar and use it as a binder there is no comparison. The road properly built with refined tar is practically as good as a bitylithic pavement. Of course a surface treatment is only a makeshift, and has to be done every year, or twice a year, but it will prove of greater

merit than a street not treated at all. It has been generally satisfactory for people who have purchased tar for that purpose. I think we ought to stop and study the matter before we sell our tar to those large concerns, at a small price.

MR. FULWEILER: Mr. Chairman, might I say one word about the surface pavement? I think that up to the last two years, we all had pretty much the same idea that Mr. Whittaker has just expressed, that surface treatment would not amount to very much as it did not stand up to requirements, but I think at the present time the idea is gaining ground that if the surface treatment is properly applied with tar binder that there is a great deal more in the surface treatment than has ever been brought out.

My argument on this point is as follows, that in no other way can you get so compact a body of stones on the surface of the road as you can by building a macadam road. There is no other method of handling material that will enable you to get so much stone in place and pack it. If we take a well built and thoroughly bonded road, which is very compact and then introduce something into the top of it that will so bind the stone particles together that they will resist the shear of the passing motor, we should have an almost ideal road surface. It is quite true that the surface treatment has to be repeated, but I think that we can now put on surface treatments at less than the interest on the extra cost of the more expensive treatments; and if we can do that, we are continually improving the surface of our roads in addition to maintaining them. Maryland, for instance, this year used the surface treatment almost exclusively. They are now building good waterbound macadam roads with thorough surface treatment. They can get relatively cheaper bids on a waterbound road with surface treatment due to the fact that you can build waterbound roads in almost any season and in rainy weather, but on a bituminous bound road the contractor cannot work before ten o'clock most of the time, and he has to quit about four-thirty unless he wants to work overtime, and

he can only work about seventy per cent. of the time owing to the necessity of working only on clear, dry days.

Of course it must be understood that to get the very best results in surface treatment, you have to use binders especially prepared for that work. I don't believe that the average water gas tar, crude, or the average coal tar, crude, will give the same result that you have, if it is more carefully prepared tar binder. They sometimes work very well and sometimes do not work at all. My experience with the surface treatment has been practically the reverse of Mr. Macbeth's. I have found that where the surface treatment fails, it is where you have a lot of horse-drawn traffic, but with the automobile traffic it has been very successful. The automobile wheels slide over it very easily, but when the horses are sharply shod in the spring or winter they scrape off the thin surface film and then the moisture gets underneath, and it begins to disintegrate.

THE CHAIRMAN: Gentlemen, the meeting now stands adjourned until two o'clock.

The session of the convention was thereupon adjourned until two o'clock P. M. of the same day.

THURSDAY MORNING SESSION.

Section A.

The meeting was called to order at 10:15 by the President, who stated that the first business would be the reading of a paper by Mr. Warren S. Blauvelt on "The Development of a By-Product Oven Gas Plant."

Mr. Blauvelt then read his paper as follows:

THE DEVELOPMENT OF A BY-PRODUCT OVEN GAS PLANT.

In December, 1899, The New England Gas and Coke Company began delivering the surplus gas from the by-product coke oven plant at Everett, for general distribution and sale as illuminating and fuel gas. The following year this pioneer plant

sold for general distribution 1,427,155,000 cubic feet of gas. During the twelve years which have nearly elapsed since the Everett plant commenced operation, the number of coke oven plants in the United States from which surplus gas is sold for illuminating purposes, has increased to eleven; the total sales of coke oven gas for general distribution have increased each year, except in 1908, until in 1910 they exceeded 12,000,000,000 cubic feet, or approximately 23 per cent. of the total coal gas sold. Of the eleven coke oven plants now delivering illuminating gas, all except one have been operated continuously since they started. In view of this record in the gas business of the United States, it is evident that the by-product coke oven method has, in the past twelve years, won for itself an enviable position among the standard methods for the manufacture of fuel and illuminating gas.

The by-product oven was originally developed primarily for the purpose of manufacturing metallurgical coke; hence, comparatively little attention was given either in the design or operation of the older plants to those problems, upon the proper solution of which, depended the success of the by-product oven as a gas retort. The yield of surplus gas was invariably low, seldom exceeding 60 per cent. of the yield obtained by good practice at the present time from similar coal. The calorific power of the gas was generally low and subject to great variations, and no satisfactory method of controlling the illuminating power of the gas had been worked out.

The first by-product coke oven plant built in this country was a block of twelve Semet-Solvay ovens at Syracuse, N. Y., which commenced operation in 1893. This plant was so successful that thirteen additional ovens were built and went into service in 1896. The same year some interesting experiments were made to determine the practicability of firing the ovens with producer gas instead of oven gas. A detached gas producer was set up; the gas was cooled, scrubbed to remove dust, and then burned in the oven flues. This early experiment was entirely successful in proving the possibility of firing ovens

with producer gas and thus securing the entire make of oven gas for general distribution.

In October, 1902, the Semet-Solvay plant at Detroit, Mich., began the delivery of its surplus gas to the Detroit City Gas Company. This plant has been used as an experiment station for working on many of the problems of design and operation of coke oven plants and the manufacture of illuminating gas. It is the author's purpose, in this paper, to tell something of the progress made during the past nine years at the Detroit plant in the manufacture of illuminating gas in by-product coke ovens.

When the delivery of illuminating gas commenced, the plant consisted of thirty ovens which had been operated about thirteen months, and thirty ovens still under construction which were completed the following December. These ovens were thirty feet long, seven feet high, with an average width of sixteen-and-a-half (16½) inches; the regular oven charge was six tons of coal. The general design of these ovens is clearly shown in the drawings Fig. 1 and Fig. 2. The oven heating flues were made of large Belgian tile; as there were four of these superimposed flues on each side of the ovens they were called four-high ovens. Clay fire-brick were used in the division walls and in the recuperator flues, which, as may be seen from the drawing, were directly below the oven chamber. The combustion gases after leaving the recuperators passed to waste heat boilers where they were utilized in generating steam, finally escaping at a temperature of about 550° F.

The general plan of the plant as it now exists is shown in Fig. 3. The oven plant as may be seen consists of four blocks, numbered 1 to 4, of thirty ovens each, a small block of six ovens built as an extension of Block No. 2 and another similar extension of six ovens at the end of Block No. 3. The sixty ovens in Blocks 3 and 4 were completed and went into service in March, 1904. These ovens were similar in design to those built previously, but were five feet longer. The heat-

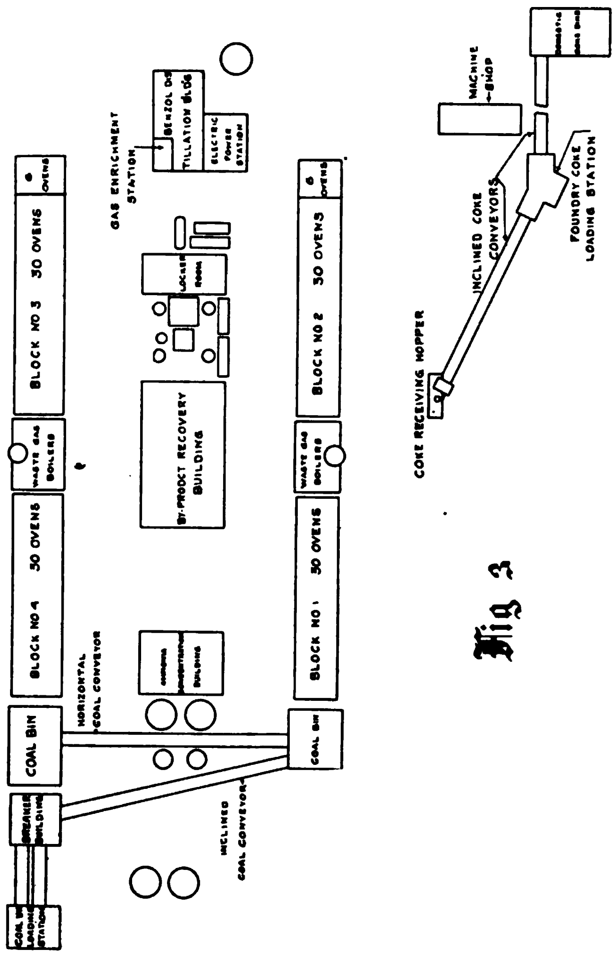


Fig 3

GENERAL PLAN
DETROIT COKE OVEN PLANT

ing flues were built of small Belgian brick instead of the large tile used in the older ovens.

The demand for coke in the district supplied by Detroit has increased every year since the plant was built, with the single exception of 1908—the year following the panic. To increase the production of the plant to meet this constantly growing demand for coke has therefore been a constantly recurring problem. From 1904 to 1907 inclusive the problem was solved by decreasing the coking time nearly four hours; by this means, coke production was increased about 16 per cent. To secure this result, however, it was necessary to operate the ovens at as high a temperature as the refractory materials then employed would stand. A further increase in the production of coke could be secured only by building more ovens or by rebuilding some of the existing ovens, increasing their size and using a higher grade of refractory material in their construction. After very careful consideration, it was determined that the latter plan for increasing the capacity of the plant would be the more profitable, although it involved the partial destruction of ovens which, after seven years service, were giving results superior to those obtained when first built, and which could undoubtedly be kept in operation for several years with comparatively small cost for repairs.

This method of increasing the capacity of the plant having been determined upon, between November, 1908, and May, 1909, Block No. 1 was enlarged (a few ovens at a time, the rest of the block being kept in operation) by making the ovens higher; the covering was taken off above the oven chambers and the oven heating flues were removed. The division walls were then built higher and new heating flues were constructed of silica brick. These ovens were called "five-high" as they have five superimposed horizontal heating flues in each side.

During the summer of 1910, Block No. 2 was rebuilt and enlarged to five-high; no change was made in the general design, but silica brick were used in the division walls and silica slabs in the oven heating flues. Block No. 3 has been rebuilt

along the same lines during the past summer, and it is planned to rebuild Block No. 4 during the summer of 1912.

In some places where large quantities of coke are consumed there is no market for gas; in other places the demand for gas far exceeds the surplus which would be produced in making enough coke to supply the local market; prices obtained for coke and gas and the cost of generating steam also vary greatly in different localities. In order to determine the type of oven best adapted for each of these varying conditions, the Semet-Solvay Company decided to build, at Detroit, several ovens of different types.

In August, 1909, six experimental ovens, built of silica material and similar in all respects to the old standard type of Semet-Solvay oven except that they are equipped with an improved and enlarged form of recuperator, were put into regular service.

With these recuperators the air used for combustion in the oven heating flues is heated to a temperature of about 1,400° F. or about 600° higher than with the older and simpler form of recuperator. The better transfer of heat from the combustion gases to the air resulted in a decreased consumption of fuel gas per ton of coal carbonized; as the combustion gases leave the recuperators about 500° F. cooler than the combustion gases leaving the old style recuperators their value for generating steam in the waste heat boilers is greatly reduced.

In October, 1909, six more experimental ovens were put into service. These ovens were arranged so that they could be fired with producer gas or with oven gas at will. Outside regenerators were provided in which both the air and the producer gas used to fire the ovens were heated. The results obtained with these ovens were quite unsatisfactory, owing mainly to leaks which early developed in the various flues connecting the ovens with the regenerators; it was therefore decided to abandon the outside regenerators and rearrange the oven heating system. Three ovens were rebuilt equipped with individual regenerators and were arranged to be fired with oven gas. Two ovens were rebuilt equipped with improved re-

cuperators and arranged to be fired with oven gas or producer gas at will. The producers—one for each oven—were built below the oven chambers at the pusher end. In the design and operation of these ovens the principles employed in the Doherty Economizer Benches were successfully used; coke was used for fuel and the entire make of gas was available for sale. These two ovens are of special interest to the gas fraternity as they were the first gas ovens[1] commercially operated in the United States.

The results of these two experiments were both quite satisfactory but there were a number of details in which it was evident that with the experience gained in five month's operation, some improvement could be made. It was therefore decided, during the past summer, to rebuild these six ovens equipping them with individual regenerators and arranging them to be fired with oven gas only, and to build three new ovens to be fired with producer gas on the Doherty Economizer System, or with oven gas at will. Construction work on these ovens is now under way.

In the following table are given the results obtained per ton[2] of dry coal coked, with various types of heating systems employed when using coal averaging 26 per cent. volatile matter, the coking period in each case being twenty hours.

In the original installation each block of ovens was equipped with a double hydraulic main, having separate compartments for rich and lean gas. Duplicate gas condensing and washing systems were provided for the rich and lean gas. Each system consisted of eight tubular condensers and two bubbling ammonia washers; a spare washer was provided which could be used for rich or lean gas at will.

As the daily coke output of the plant was increased, it became necessary to enlarge the capacity of the gas condensing and washing apparatus. After a series of experiments with a Doherty washer-cooler, it was decided in 1909 to replace the tubular condensers and the bubbling washers with this type of

[1] By-product coke ovens so designed and operated that all of the gas distilled from the coal carbonized therein is available for sale.

[2] 2,000 lbs.

RESULTS WITH VARIOUS TYPES OF SEMET-SOLVAY OVENS AT DETROIT.

Type number	1	2	3
Number flues high	4	5	5
Material—Division walls	Fire-clay	Fire-clay	Silica
Material—Oven flues	Belgian tile	Silica	Silica
Air heated in	Sole flue Recuperators	Sole flue Recuperators	Sole flue Recuperators
Fuel gas required—Cu. ft.	6,800	6,200	5,500
Fuel gas—B. t. u.'s per cu. ft.	525	517	505
Surplus gas—Cu. ft.	3,900	4,500	5,200
Surplus gas—B. t. u.'s per cu. ft.	610	610	610
Lbs. steam from waste heat	950	900	800

Type number	4	4
Number flues high	5	5
Material—Division walls	Silica	Silica
Material—Oven flues	Silica	Silica
Air heated in	Improved Recuperators	Improved Recuperators
Fuel gas required—Cu. ft.	5,300	.....
Fuel gas—B. t. u.'s per cu. ft.	501	.....
Surplus gas—Cu. ft.	5,400	10,700
Surplus gas—B. t. u.'s per cu. ft.	610	556
Lbs. steam from waste heat	400°	500°
Lbs. coke required for oven fuel	...	235

° Estimated

apparatus. Four single compartment washer-coolers, each eight feet in diameter, were installed to be used as condensers; two of these are used in series to cool the rich gas; the other two also in series, cool the lean gas. A four compartment washer-cooler, each section eight feet square, which had been used in the preliminary experiment, was put into regular service as a final ammonia washer for rich gas. A five compartment apparatus, each compartment 7 ft. 6 in. square, was installed as a final ammonia washer for the lean gas. Each set of apparatus has been found by actual test to be of ample capacity to handle 10,000,000 cu. ft. of gas daily. The ground area occupied by the new condensing and washing plant is only two-thirds that required by the old apparatus of half the present capacity. The gas condensing and washing systems are shown in diagram on Fig. 4 and Fig. 5.

When gas deliveries commenced, the nitrogen content varied from 3 per cent. to 12 per cent. and the calorific power varied as much as 75 B. t. u.'s per cubic foot. This difficulty was obviously due to leakage through the oven walls induced by variations in pressure. It was, of course, owing to the permeability of refractory materials, impossible to absolutely prevent leakage through the oven walls if the pressure within the ovens or in the adjacent heating flues differed materially from the atmospheric pressure. To prevent leakage therefore, it was necessary to devise a method which would automatically control the gas pressure in the ovens. Experimentally it was found that a satisfactory yield of gas, uniformly low in nitrogen, that is to say, below 4 per cent., could be obtained from a block of coke ovens only when the variations of gas pressure in the hydraulic main was less than 3/100 of an inch water column. About two years was consumed in developing a practical governor capable of controlling the pressure variations within these narrow limits. During these two years, the only practical method of avoiding leakage of air into the ovens, was to run with so high a mean pressure, that the pressure in the ovens was above atmospheric pressure, even when the pressure at the hydraulic main was lowest; as a result the loss

Fig 4

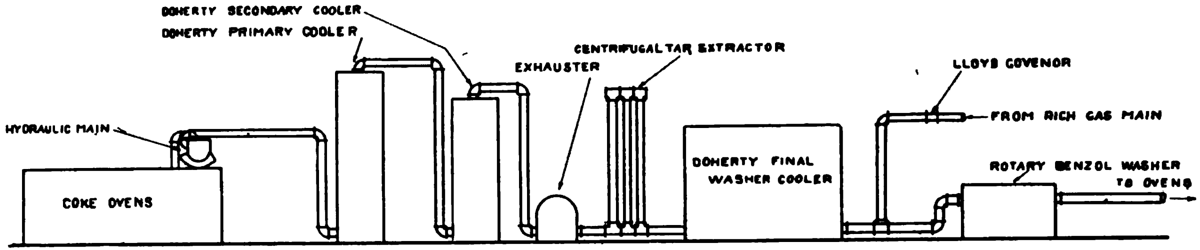


DIAGRAM OF FUEL GAS SYSTEM

Fig 5

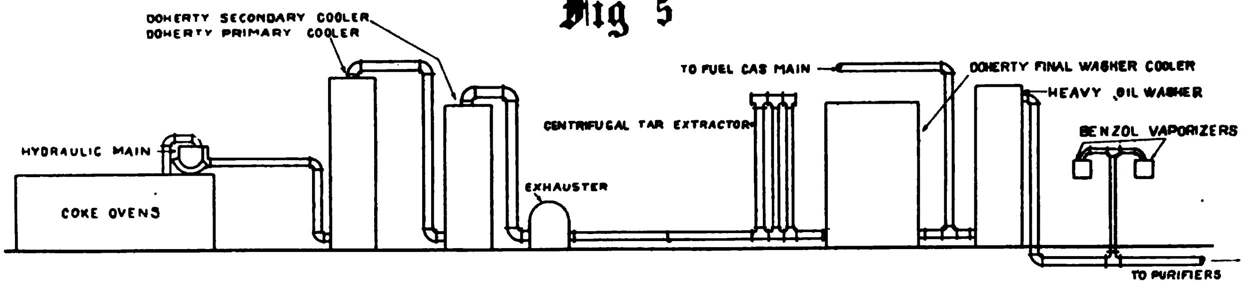


DIAGRAM OF RICH GAS SYSTEM

of gas, due to leakage from the ovens, was excessive and the yield of surplus gas was materially reduced.

After successful pressure controlling mechanisms were devised and installed, it became a comparatively simple matter to control the calorific power of the gas. From the coal used at this plant, the gas produced during the coking process varies from about 700 B. t. u.'s per cubic foot when an oven is freshly charged to about 350 B. t. u.'s per cubic foot at the conclusion of the coking period. If all the surplus gas were the richest portion, it would average about 650 B. t. u.'s per cubic foot; as the gas from any oven may be delivered to the rich or lean gas systems at will, it is obviously a comparatively simple matter to so vary the separation as to deliver all the surplus gas at any required calorific power between 500 and 640 B. t. u.'s per cubic foot. In practice it is customary to vary the calorific power as the illuminating power is changed as given in the following table:—

15 candle-power gas	605 B. t. u.'s
16 " " "	620 "
17 " " "	635 "
18 " " "	640 "

As no gas-holder is used, calorific determinations made on the gas, as delivered direct from the plant, frequently vary as much as 20 B. t. u.'s from the standard, but the average of all determinations for a period of twelve hours is seldom more than 5 B. t. u.'s below, or more than 10 B. t. u.'s above the standard required.

In order to insure the control of the illuminating power of the gas delivered so as to meet the requirements of the Gas Company, a water gas set was installed; and water gas was used for enriching until March, 1904, since which date benzol has been used for this purpose. Benzol enrichment proved quite satisfactory till the following winter; then trouble began. When the temperature dropped, illuminants condensed and the candle-power was low; with a rising temperature, this condensate was taken up by the gas and the candle-power was too high. This difficulty was reduced somewhat by the use of

a higher grade of benzol during the winter months, but it was not entirely overcome until 1908, when apparatus was installed for washing the gas before enrichment, with an absorbing oil which removed practically all of the naphthalene and other condensible hydrocarbons. Since this apparatus has been in use there has been no appreciable difference between the candle-powers observed immediately after enrichment, and those observed at the Gas Company's station about 2½ miles distant; and the enriching value of the benzol used has been as high in the winter months as during the summer.

At the Detroit plant the production of an exceptionally high grade of foundry coke has always been considered of first importance; to secure this desired result, it was early discovered that a better quality of foundry coke could be made from a mixture of coals—one of which is very low in volatile matter—than from any one coal coming into the Detroit market. The best foundry coke has been made from a coal mixture containing from 25 to 26 per cent. volatile matter; from such a coal the yield of gas, and other volatile products, is necessarily much lower than would be obtained from a good gas coal containing 32 to 34 per cent. volatile. Nothwithstanding this handicap, the normal yield of gas per ton of dry coal, the nitrogen content in the gas not exceeding 4 per cent., varies from 10,400 to 10,800 cubic feet when coking in twenty hours. With higher heats and a shorter coking period the total make of gas is materially increased; no accurate determinations have been made of this increased make of gas due to higher oven temperatures, but the results obtained from the entire plant when one block was operated for several weeks at 16 hour coking time, indicates that the yield of gas per ton of dry coal from this block approximated 11,500 cubic feet.

As the design and operation of by-product ovens have been improved, additional knowledge has been gained as to the kinds of coal best adapted for use in the manufacture of the various grades of coke desired in different industries: and much has been learned of the effect of different rates of carbonization on the quality of coke. As a result of this in-

creased knowledge, grades of coke specially adapted to various uses are now made, and the prejudice, formerly existing in the iron industry, against by-product coke has almost entirely disappeared.

The sale of crushed coke, mainly for use as domestic fuel, is increasing rapidly as shown by the sales from the Detroit plant, which during the last three years were as follows:—

1908	42,797 tons
1909	62,704 tons
1910	106,385 tons

Sales to date this year indicate that at least 150,000 tons of domestic coke will be delivered in 1911.

During the past decade all of the difficulties which tended to prevent the successful operation of a by-product oven gas plant, in a suitable location, have been satisfactorily overcome. In thermal efficiency and in total yield of gas, the by-product oven compares favorably with the best gas benches; the development of the type of oven which may be heated by burning producer gas or oven gas at will, provides a simple and satisfactory method of adjusting the daily make of gas to the demand, without changing the rate of carbonization; variations in the heating and illuminating power of oven gas may be controlled within very narrow limits; all doubt about the possibility of disposing of a greatly increased tonnage of by-product coke has been removed in great sections of the country, by its general adoption for use as a metallurgical and domestic fuel.

The achievement of these results in the development of the by-product oven method of carbonizing coal makes possible in the manufacture of coal gas on a large scale, those economies in construction and operation due to the use of large units, which have proven of such enormous value in the manufacture of iron and steel, in transportation by rail and water, in generating electric power and in digging the Panama Canal.

The President: Gentlemen, the Chairman of the Technical Committee has suggested—and I think it is an excellent idea—

that before opening for discussion the paper which has just been read, we have read the next two papers, one on "Operation of Verticals in Providence," by Mr. Carroll Miller, and the other "Report on Verticals at Manchester," by Mr. W. G. Africa. The subjects are so near akin to each other that the speakers would naturally want to branch from one subject to the other, and I am therefore going to call for those two papers next; but before doing that, I want to say that several members have asked me as to whether or not Prof. Bone was really in town, whether he was really going to deliver his lecture and whether it was really worth hearing. I am glad to be able to answer all three questions. Prof. Bone is here, he is in excellent health; he is going to deliver his lecture in this hall at two o'clock, and from the preliminary outline of it which he gave to me, it is better worth hearing than anything we have heard for a great many years. I now call on Mr. Carroll D. Miller for his paper on "Operation of Verticals in Providence."

Mr. Miller then read his paper as follows:

OPERATION OF VERTICALS IN PROVIDENCE.

The new coal gas plant of the Providence Gas Co. was described in a paper read last February before the New England Association of Gas Engineers and I will therefore repeat here only the portions of that description that are necessary to this paper which deals with the conditions in and the operation of the settings.

The retort installation is of the Dessau type and has been in operation nearly a year. Two stacks each containing six benches of ten retorts have been in use for that time, the third stack not having been charged. The retort is 13 ft. 2 in. long, 22½ in. by 9 in. at the top and 27 in. by 14 in. at the bottom and is 3 in. thick at the top and increases to 4 in. at the bottom. The retorts are in two rows of five each, the producer being at the side lengthwise of the bench. The producer gas and air enter the setting at six places, four between the retorts and one at either end of the bench.

There is one producer for each bench, the size of the grate being 3 ft. 4 in. by 4 ft. The total depth from the grate bars to the charging door is 18 ft. but, as the producer gas is taken off at a point about 3 ft. above the grate, that figure represents the active depth, when the fire is clean, the remainder of the height being available for storing coke.

The combustion takes place at the bottom of the retorts, the products making four horizontal passes, alternately away from and towards the producer, leaving at the top of the setting, down through the recuperators and under a steam generator, which supplies steam to the fire, thence to the main flue.

During the first few months we had great difficulty in keeping the retorts hot enough at the tops without getting the temperature too high at the bottoms, where it would exceed 2,500° F. and yet not hot enough at the tops to carbonize the charges. We did not then determine the top temperature but it probably was not higher than 1,500° F., a difference of 1,000°. By making some changes, the difference was reduced to about 500° and the highest temperature to 2,300°. These changes led up to the below described tests, which were planned and conducted by Mr. E. R. Hamilton, Chemist of the works.

I will only give the results of the second series of tests as the first were not complete due to some of the junctions getting out of order and breaking. The figures obtained in the first substantially check with those of the second series.

A retort was selected in the row farthest removed from the producer, on account of its being more available for placing the thermo-couples. Temperatures were taken at four points outside the retorts and at corresponding heights on the outside and center of the charge (See Fig. 1). A Wanner radiation pyrometer was used for taking the outside temperatures at the lower passes and base metal thermo-couples at the other points. Temperatures were also taken at the top of the charge, the thermo-couple entering about 3 in. into the coal. Two 1¼ in. pipes were inserted into the retort through

the top lid, one pipe resting against the side wall and the other held in position in the center of the charge. Two 13 ft. and two 8 ft. asbestos covered junctions were used; one

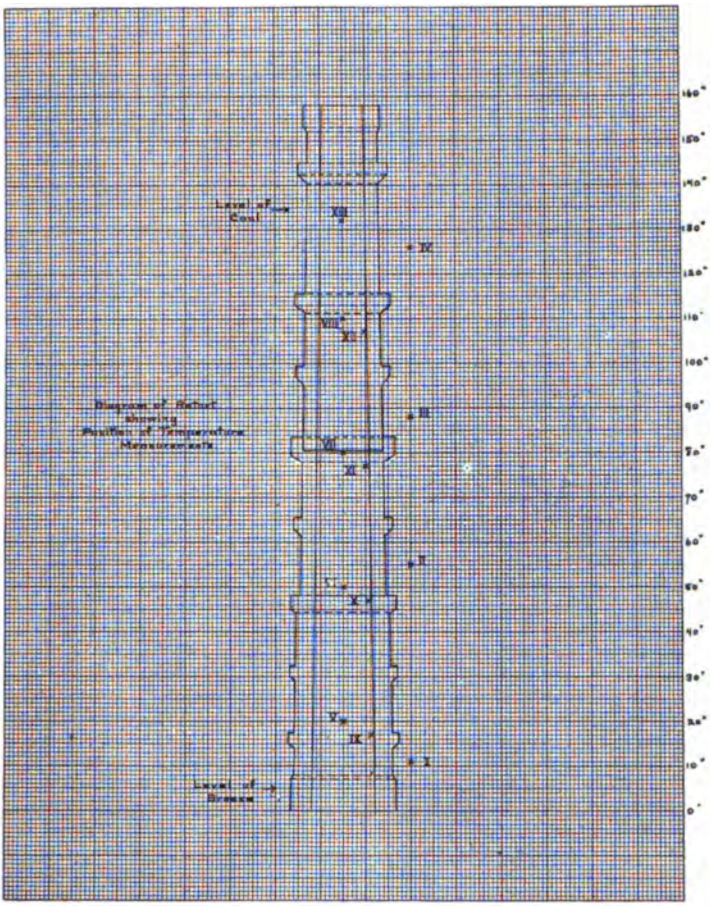


Fig. 1.

of each was placed in a ¾ in. pipe and this pipe inserted into the 1¼ in. The smaller pipes, containing the junctions, were moved up and down to get the temperatures at each two corresponding points.

The temperatures were plotted into curves. The outside temperatures are shown in Fig. 2 and the inside in Fig. 3. The curve numbers correspond to the position numbers in Fig. 1.

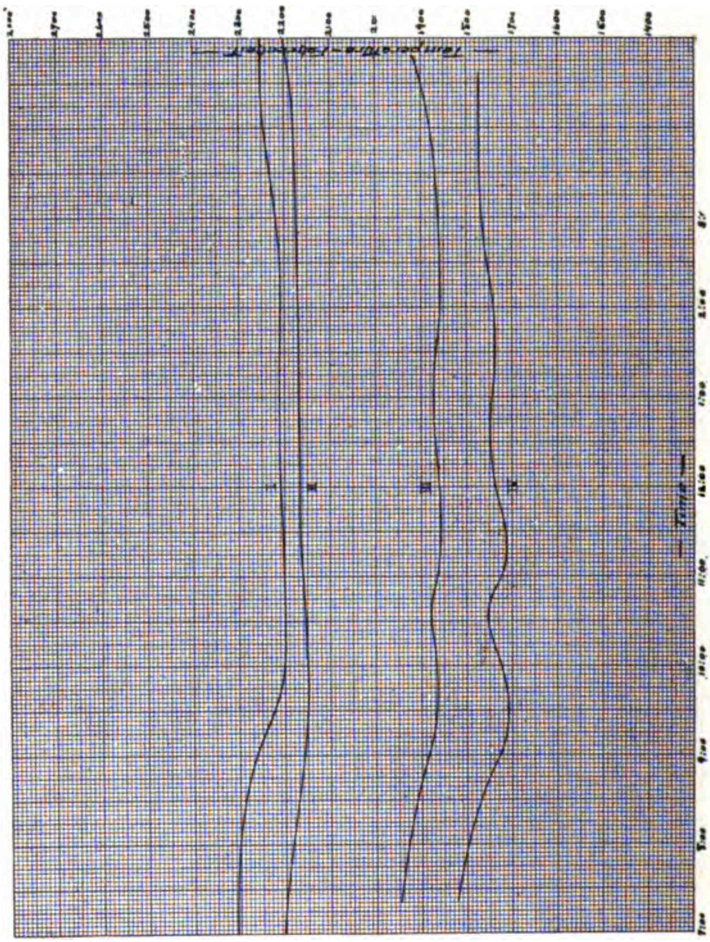


Fig. 2.

Curves 6, 8, 10 and 12 were not started until 10:00 A. M. because no readings were taken in those positions before that time as we desired to take reading, during the beginning of

the charge, at five minute intervals in order to show the sudden variations in temperature. It was impractical to move the couples every five minutes and the readings, at fifteen minute intervals, which were taken after 10:00, would not have

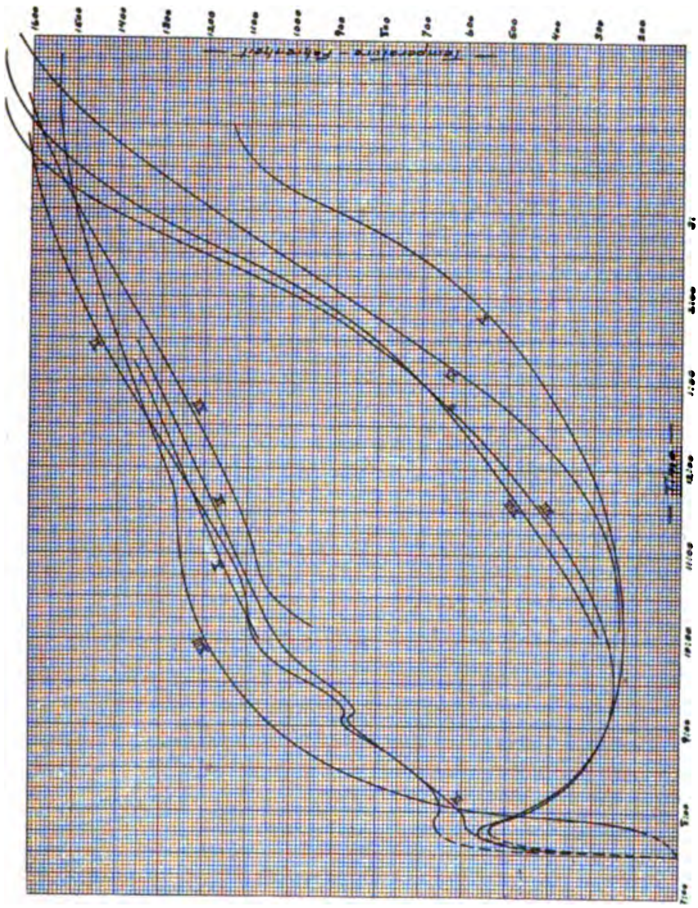


Fig. 3.

shown these changes. Before 10:00, doubtless these curves would approximate 5, 7, 9 and 11 respectively. Curves 9 and 10 stop at 1:30 P. M. because the couple broke.

The retort had been scurfed just previous to the test.

Bench No. 2, Retort No. 7.
Date of test—August 11, 1911.
Coal charged—1,100 lbs.
Moisture—1.05 per cent.
Volatile matter—33.23 per cent.
Ashes cleaned out of fire 8:00 A. M.
Fire raked up 11:00 A. M., 2:30 and 4:30 P. M.

Some analyses of coke taken from various parts of the retort lead us to believe that the coal is thoroughly carbonized when it attains a temperature of about 1,500° F. However, in considering the equal heating of the charge, this figure need not be considered. Curves 5, 6, 7 and 8 would indicate that the temperature is too low at the bottom; that the coal at position 7 is carbonized about 15 minutes before that at 8 and an hour before 6. We raised the bottom temperature slightly and obtained better results; yet, some portions of the charge were heated more than others, thus causing a waste of fuel.

The curves would indicate that a thinner charge would be desirable. Although the temperature outside the retort at the bottom is higher than at any other point, the temperature at the center remained far below the upper points. This may be accounted for by radiation from the lower mouthpiece as well as by the thickness of the retort and charge.

The object of this paper is to describe the operation of our settings and therefore I will not here go further into the data at hand. However, it seems that from these tests there may be calculated the heat transmitted through the retort wall and body of coal for the various thicknesses and corresponding temperatures, which might be of some value in designing and applying heat to a retort setting.

In table 1 are the results of operations for each month during this year to July, 120 retorts being worked.

From time to time, we have changed our methods of operating which accounts, to a great extent, for the variations in the results. Explanation of the various items in Table 1 and our methods are given below. Mr. T. H. Hintze, Superin-

TABLE 1.

	January	February	March	April	May	June	July
Time of charges	15 days, 10 hrs. 16 days, 9 hrs.	15 days, 9 hrs. 13 days, 10 hrs.	10 hrs.	10 hrs.	10 hrs.	24 days, 10 hrs. 6 days, 11 hrs.	12 days, 11 hrs. 19 days, 10 hrs.
No. of retorts charged	8,996	8,115	8,484	8,192	8,329	7,724	8,173
Average weight of charge	962 lbs.	957 lbs.	990 lbs.	980	1,022	1,032	979
Gas made, M's cu. ft.	42,775	37,739	41,608	39,522	40,910	38,132	42,595
Gas per lb. of coal—cu. ft	4.93	4.85	5.00	4.91	4.81	4.78	5.32
Candle-power (flat flame, Bray No. 7)	13.00	12.78	12.70	13.40	14.40	14.12	12.05
Candle feet	64.10	61.98	63.50	65.80	69.30	67.49	64.10
Calorific power	615	637	625	605	606	627	637
Bench fuel per 100 lbs. of coal	19.64	19.11	18.87	18.78	18.62	19.46	20.34
Gas per ton (2,240 lbs.) of coal, cubic feet	11,043	10,864	11,200	10,998	10,774	10,707	11,917
Tar per ton (2,240 lbs.) of coal, gallons	13.50	15.80	16.60	15.94	17.30	17.74	12.30
Ammonia per ton (2,240 lbs.) of coal, pounds	5.29	6.27	6.30	7.05	6.462	7.085	6.825
Coke made, per cent. of coal	70	70	70	70	70	70	70
Coal handled per man per day, tons.	12.477	12.353	12.006	11.957	12.258	11.9	11.361

tendent of the Works, has worked out much of the data given in this paper.

Carbon forms in the retorts very rapidly, particularly in the lower portions. We have tried various methods to reduce the time of scurfing but the average time taken has not fallen much below forty hours, each retort being scurfed every twenty days thus causing a loss of capacity, from retorts being off, of something over eight per cent. In addition to this, the amount of coal charged per retort decreases as the carbon increases. The average amount of carbon removed from a retort after being twenty days in service is 44 lbs. or 0.628 cu. ft., which is equivalent in volume to about 33 lbs. of coal, an average loss of 16.5 lbs. per charge or about 1.6 per cent. Some recent experiments, that we have made, would indicate that the scurfing time may be reduced to a few hours.

The pressure of gas at the bottom of the retort is from 10 to 12 inches of water during the first period of the charge and 3 to 4 inches during the last few hours.

Sometimes, the charge hangs in the retort which seems to be generally due to the extreme bottom of the retort being too cold.

We have made some experiments to determine the differences between the illuminating powers of the flat flame and argands. The Sugg D averages about 3 c-p. higher and the Metropolitan No. 2 from 6 to 7, when tested with gas of from 12 to 14 c-p. in the flat flame.

Coal is fed into the storage bins with a belt conveyor, the chute of which constantly travels the full length of the retort house. This chute passes over a little hopper which is made of such a size that it collects about one-quarter of one per cent. of the coal going into the bins. These samples are collected weekly and crushed, quartered and analyzed in the usual way.

The coke is sampled and analyzed weekly.

The take off pipes from the retorts are cleaned every two days.

The hydraulic mains are equipped with pans, one under each

dip pipe. These pans, which catch the thick tar and pitch, are emptied once a week. The dip pipes are only sealed when the retorts are being discharged.

The producer fires are clinkered (with secondary bars in place) every 48 hours, ashes cleaned out (without the use of secondary bars) 24 hours after clinkering and the fires are raked between the grate bars every three hours.

The coke charged into the producers is measured by volume, the measures having been standardized with kiln dried coke. All coke sold and used for other purposes is similarly measured. Large coke was at first used in the producers but we are now using two-inch coke as it gives a better producer gas on account of a larger hot surface being exposed.

The amount of coke burned in the producers per sq. ft. of grate surface per hour varies from 14 to 16 pounds.

Mr. Miller: I might add here that I originally had in the table analyses of the coal for each month, but we found there was some doubt about the methods in taking the samples, so I omitted them. The coal that we have been getting recently would average about, moisture, two per cent., volatile matter, thirty-four to thirty-five per cent, ash, seven to eight per cent., and the corresponding coke on a dry basis two and one-half to four per cent volatile matter and ten to eleven per cent. of ash.

The President: Before the papers are discussed we will hear from Mr. W. G. Africa on "Report on Verticals at Manchester."

Mr. Africa then read his paper as follows:

VERTICAL RETORTS AT MANCHESTER, N. H.

In the winter of 1907-'08 we erected two benches of nine vertical retorts each.

Only one of these was equipped for operation, and its behavior was mentioned in the Proceedings of 1908.

We then decided to try different sized retorts in order to

find what size and taper was best suited for our coals. To do this, we tore out the retorts of the bench we had previously started, and put in five retorts of four different sizes and tapers. These retorts varied from 20 by 34 ins. at the bottom to 16 by 22 ins. We finally chose the latter as being best suited for our setting although all worked well.

The two benches were then equipped with this size retort, eighteen in all, and the plant provided with a shelter over the retorts and the recuperator side of the bench; the rest was left exposed to the weather.

We started charging the retorts about June, 1910, and with the exception of a shut-down to change the closing devices, which were defective, the setting has been running since and has been most promising. At first we were troubled with the lower lids leaking badly, but by adding a clinching device we have reduced this leakage to a point where it is of no consequence.

Three retorts are charged and discharged at one time, they being connected to one gas take-off.

We have in all our experiments with these retorts had unusually high candle-powers for vertical retort systems, and this we attribute to the fact that we leave a space of four feet, of heated retort above the coal for the gas to pass through, thus fixing the vapors which, in systems of full retorts, do not reach the proper temperature for gasification.

A test was made the early part of this year, in which all apparatus was carefully standardized and tested, and facilities provided to get most accurate results.

Candle-powers and calorimeter readings were taken at frequent intervals through a mixing tank. A pentane lamp was used for the photometrical standard, and a Junker calorimeter for calorific values.

Both tar and ammoniacal liquor were collected in isolated tanks, and carefully measured and analyzed.

Coke results were obtained by weighing the coke hot.

The coal used was ¾ in. screened from Farmington, W. Va.

The following is a summary of the test:—

Yield per lb	5.59 cu. ft.
Yield per net ton	11,180 cu. ft.
Yield per gross ton	12,522 cu. ft.
[1]Average candle-power, flat flame	13.47
Average candle-power, Sugg D	16.47
Average candle-power, Met. No. 2	18.97
Candle-feet, flat flame	75
Candle-feet, Sugg D	92
Candle-feet, Met. No. 2	106
Calorific value, per foot	600 B. t. u's.
Calorific value, per pound	3,353 B. t. u's.

RESIDUALS.

	Per net ton	Per cent. coal
Coke	1,350 lbs.	67.5
Tar (dry)	14.4 gals.	6.73
NH_3	6.17 lbs.	....

Furnace fuel was 13.27 per cent. of coal carbonized, or combustible charged into furnace, 11.77 per cent. If allowance is made for fuel in ash thrown out, this figure would be lower.

These benches are, as stated above, exposed to the weather, and the thermometer went close to zero at night during the test.

On page 504 are given the working results for the past five months, West Virginia coal from Lincoln Mines was used shipping weights taken and allowance made for 2½ per cent. moisture:—

The furnace fuel did not show up as well as in the short test above, due to various reasons, the principal one being that the coal used contained considerable slack due to being broken up by frequent handling en route; this slack requiring more heat to burn off than clean lumps.

The wide variation in the monthly yields is not due to a lack of uniformity in the operation of the benches, but is caused by the necessity of periodically charging off discrepancies in the coal stock, that accumulate from losses in shipment, etc.

[1] Candle-power readings were taken with a flat flame burner, but a number of readings were taken with the Sugg D and Metropolitan No. 2 to establish their relative values.

	April	May	June	July	August	Total & Av.
Corr. gas made M. cu. ft....	6,782	7,324	7,072	7,074	7,213	35,493
Coal carbonized, lbs.	1,229,003	1,306,150	1,256,305	1,210,500	1,336,325	6,338,288
Aver. weight per charge....	914 lbs.	911 lbs.	945 lbs.	925 lbs.	9.50 lbs.	929 lbs.
Yield per lb., cu. ft.........	5.52	5.28	5.63	5.84	5.40	5.69
Aver. c-p. flat flame, 70° F..	13.90	13.70	14.10	14.85	13.87	14.08
Aver. c-p. Argand "D", 70° F	16.90	16.70	17.10	17.85	16.87	17.08
Aver. c-p. No. 2 Met., 70° F.	19.40	19.20	19.60	20.35	19.37	19.58
Candle-ft. per lb. flat flame, 70° F	76.73	73.71	79.38	86.72	74.90	78.71
Candle-ft. per lb. Argand "D", 70° F............	93.29	89.85	96.27	104.24	91.10	95.48
Candle-ft. per lb. No. 2 Met., 70° F	107.09	103.30	110.35	118.84	104.60	109.45
Coke used, furnaces lbs.....	180,905	196,950	175,740	157,680	184,525	895,800
Coke used, furnaces per ton coal, lbs................	295	302	280	260	276	283
Coke used, furnaces, per cent. coal carbonized....	14.7	15.1	14.0	23.0	13.8	14.15

We have had no trouble from coke not discharging freely, except when the charges are not burned off. This, however, seldom occurs.

Both primary and secondary air are measured with Venturi meters, and the average CO_2 in waste gases is close to 19 per cent.

We are adding two benches of nines to our plant this Fall, which will give us a total capacity of 500 M per day.

A similar plant of five benches of nines is also being erected in Philadelphia, and will be in operation shortly.

In their present form, we regard our Manchester verticals as a marked success.

THE PRESIDENT: Gentlemen, we have before us three extremely interesting papers. They are all open to discussion by the members. I shall be glad to hear from any gentleman who wishes to discuss them, including the authors of the papers.

MR. G. T. MACBETH: I should like to ask Mr. Miller and also Mr. Africa whether the variations between the flat flame and the D burner were constant?

MR. FULWEILER: There are several points in the paper on coke ovens that I should like to speak of. On page 484, is it the permeability of the refractory material or large number of joints that is essentially the cause of a rather excessive leakage in the coke ovens? Under the ordinary conditions in gas retorts the pores in the material itself, after having been in use for some time, will tend to become filled with carbon and thus become more or less gas tight, but with joints or cracks this action does not seem to take place so rapidly or so thoroughly.

In their work on controlling the variations of pressure in the hydraulic main, do they find any trouble with vibrations which seem to be set up by the action of the exhausters? The average of the gauge readings will show uniform conditions, but the periodic vibrations seem to cause considerable leakage, both of air and of gas, in the retorts themselves.

In the question of benzol enrichment where the gas was oil scrubbed, is it to be understood that speaking from a standpoint of condensible vapors the gas is practically dried before adding the benzol, so that there would be no other condensible hydrocarbons present to complicate the action of the regular vapor tension laws?

In speaking of rapid carbonization, Mr. Blauvelt did not express an opinion as to which direction this worked, and I should like to ask him to express an opinion (if he cares to do so) as to how their experiments resulted. In some cases it has been understood that a very rapid carbonization tended to give a loose or friable coke, while further experiments have led to quite the opposite result, depending, apparently, somewhat on the conditions rather than on the rate of carbonization.

On the latter part of page 492 Mr. Blauvelt speaks of a suitable location as apparently being one of the essential features in the successful operation of by-product coke ovens. Is it not a fact that the location in regard to a market for a very large quantity of coke is one of the predetermining factors in the success of a by-product coke oven plant, or does Mr. Blauvelt believe that such a market can be worked up under almost any condition?

In discussing Mr. Africa's and Mr. Miller's paper, it is somewhat difficult, of course, to compare the results because the coal used was not the same, but they were probably of the same general type. It seems very probable that the apparently better results obtained by Mr. Africa might be due to the different methods of carbonization followed at these two plants, and which Mr. Africa very briefly touches upon when he mentions the existence of free space above the charge in the vertical retorts at Manchester. We know that in the ordinary horizontal retorts there is a rather excessive highly heated free space above the charge at the top of the retort. We also know that in some types of vertical retorts that are completely filled no free space exists, and we believe that the gas as it is given off from the coal is practically saturated with

a mist of heavy hydrocarbons, and that some at least of this hydrocarbon mist, if properly handled, seems to be capable of fixation into gases and vapors that will be carried by the bulk of the gas formed from the coal. It seems that it is the efficient fixation of this vapor that may explain the difference in the results between the two systems.

In the completely filled vertical retort, as before mentioned, no free space exists, so that there can be no secondary fixation of the tarry vapors, but in the system of vertical carbonization at Manchester the free space can be regulated both as to height, and therefore extent, and the temperature can also be regulated; furthermore, this free space is of considerable area, so that the polymerization which takes place in the vapors is due, in large measure, to radiant heat and not to conducted heat. The difference in the action is apparent when we consider a horizontal retort that is charged practically full. Here there is also a small free space, but the gas in passing over the coal is brought into intimate contact with the top of the retort, so that practically the heating is all done by conduction. Furthermore, in the horizontal retorts the free space is in the upper part of the retort, which is also the hottest portion because there is less heat being withdrawn at this point and you cannot modify or control this temperature, whereas in the vertical system with a free space you can very readily make the temperature in the top section almost anything you please, and can, as mentioned above, either enlarge or reduce the heated area.

If we compare analyses of the tars produced by the different systems of carbonization, correcting the observed gravity and coke for the effect of free carbon, we find that the tars arrange themselves in the following series. Continuous verticals, ordinary verticals without free space, verticals with free space, chamber ovens arranged to produce illuminating gas, coke ovens, low temperature horizontal retorts and high temperature horizontal retorts. The correct gravities rising steadily from 1.06 to 1.16, the free carbon rising from 3 to 35 per

cent., the coke formed rising in about the same ratio, and the unsaponified material falling from 12 per cent. to a fraction of 1 per cent., all of which tends to show that more and more complex hydrocarbons are formed in the tar as the temperature of polymerization rises or comes into existence, and is effected first by purely radiant heat, and in the end by purely conducted heat. It seems, therefore, that we must use the proper mean position where there shall be a certain definite amount of free space to effect polymerization, and yet be able to regulate the temperature and effect it by purely radiant heat.

With regard to the furnace fuel at Worcester, they seem to use something approximating 19 per cent., and at Manchester only about 14 per cent. This seems a considerable difference, and we consider that the two fuels apparently contain about the same fixed carbon and ash, and it is undoubtedly effected by the rate of combustion per square foot of grate. At Providence they seem to report about 14 to 16 pounds per square foot of grate, while at Manchester it is about 5 or 6 pounds.

Mr. W. H. Blauvelt: Mr. Miller gives us the coal handled per man per day. I should like to inquire whether that is hand labor or what other item it includes. At the bottom of the table on page 499 I should like to ask Mr. Africa how the labor on his verticals compares with the figure which Mr. Miller gives us.

Mr. A. E. Forstall: I notice in the paper by Mr. Blauvelt that following recent scientific practice he gives his results in terms of tons and pounds of dry coal. Being one of the old-time gas men who has been accustomed to take the material as he found it and figure his results from that, I should like to know what would probably be the average percentage of moisture in coal as handled, so that I can check up the figures for dry coal as compared with the figures for coal as it runs.

In the table on page 499 I notice that the total amount of gas made which is divided between fuel gas and surplus gas, is constantly 10,700 feet per ton. That raised the doubt in

my mind as to whether the fuel gas was metered, because it did not seem to me, that throughout the varying conditions that must have come with the changing of the furnaces, the yield of gas could have been exactly the same all the time. I should like Mr. Blauvelt to say whether the gas was metered.

In connection with Mr. Miller's paper I could not quite understand why his coal sampler did not work, because I was under the impression that the coal was crushed before it was put into the storage bin for vertical retorts, and if it was crushed I should think that the sampler ought to give a pretty good sample.

In the main table given by Mr. Africa I had a little difficulty at first to understand the meaning of the last line "calorific value per pound," but after thinking it over I presume that means the calorific value of the gas produced per pound of coal carbonized.

Referring to what Mr. Fulweiler said about the difference between the effect of radiant heat and conducted or convected heat on the character of the gas produced, I think it would pay the members of the Institute to go back through the volumes of the Journal of Gas Lighting, using as a guide the index published in the number for September 12, 1911 and read the lectures and papers presented to various gas Associations in Great Britain by the late Mr. William Young. He went into that subject of the difference in the effect between radiant heat and conducted or convected heat very thoroughly, and his experiments and his deductions seem to have proved quite conclusively that there is a selective action of radiant heat, by which it breaks down the heavier hydrocarbons into lighter and permanently gaseous hydrocarbons, and if you can properly proportion the amount of radiant heat to which the gas is subjected, after it goes off from the coal and before it leaves the retort, you do get very much higher results than if you do not have the effect of this radiant heat. It has always seemed to me a strong point in favor of vertical retorts, that by experiment you can get exactly the amount

of free space and therefore the amount of radiant heat which give the best results for the kind of coal that you are using and in the actual process of working give that amount of free space very closely without going to any refinement. It is also possible to do this in a horizontal retort, but it is not as easy to get the same amount of space for each charge as it would be in the vertical retort, where variations of a couple of inches in the depth of the charge would not make a great percentage of difference.

MR. HARTMAN: I note in Mr. Blauvelt's paper that "The air is heated in the recuperators to a temperature of about 1,400 degrees." This is undoubtedly good for recuperator practice, but in the coke oven industry as also in the steel and glass industries regenerators are known to be much more efficient than recuperators, and a temperature of 2,000 degrees for secondary air is not at all unusual in coke oven practice.

I note also that they have experimented with coke ovens with individual regenerators, but I do not see any reference to this in the table of results. Further along I note that they are going to build or are building more of this type; therefore, the results we would infer must have been promising. It would be interesting if the author would give us some of the figures referring to those individual regenerator settings.

Regarding the Providence verticals, we note that these results are all given per gross ton of twenty two hundred and forty pounds. I figure the gas per ton of 2,000 pounds is 9,880 cubic feet. It would be interesting to know something of the quality of coke from these vertical retorts, and whether it is adapted for use in foundries as well as for domestic purposes.

Carbon trouble seems to be very excessive at the Providence plant, their capacity being reduced over eight per cent., and I note that sometimes the charges stick, probably due to the extreme bottom of the retort being too cold. I would rather suspect it might be due to the carbon. The pressure is given in the Providence retorts of from ten to twelve

inches of water during the first period of the charge and three to four inches during the last few hours. In that connection I should like to read a few pressures I had taken the other day on a by-product coke oven with a 13.6 ton charge of coal. The coking time was 18 hours and 45 minutes. The pressures 15 minutes after charging at the top were 25½ millimeters of about one inch; at the bottom 30 millimeters. One hour and 35 minutes after charging, the pressure at the top was $2^{8}/_{10}$ths millimeters; at the bottom 3 millimeters. Four hours after charging the pressure at the top was $2\,^{2}/_{10}$ths millimeters, at the bottom 3 millimeters. Eighteen hours after charging the pressure at the top was $2\,^{2}/_{10}$ths millimeters and at the bottom 3 millimeters. Therefore, I do not understand why the pressure should be so high in the bottom of the vertical retort. It must certainly interfere with the proper and scientific operation of a coal carbonizing system to have the difference of pressure so great between the top and bottom of the retort.

I note also that at the Providence plant the fuel is a selected fuel, it being two inch coke before being used. Regarding the Manchester plant I think it would be interesting to know something of the pressure in the retorts, the temperature outside of the retorts, the temperature of the secondary air and the temperature of the stack gases. I note that in the Manchester plant a number of changes were made in order to adapt the retorts as to size and taper to the coal. That appears to be a very serious point with the vertical retorts. You have to adapt the retort to the coal or you are restricted to the kind of coal you can use. Further along: "The lower lids were leaking badly, but have now been changed reducing the leakage to a point where it is of no consequence." I would consider that any leak at all is of consequence.

We note here that the coal is a picked coal again, three-fourths of an inch screened from Farmington coal. The slack you understand is all taken out. In fact, I understand

that at this plant one time they ran out of lump coal and were obliged to use slack and were seriously handicapped with carbon trouble. This Farmington coal is a very rich coal. I have the analysis of the Farmington slack coal, but not with me. The slack coal with an ash content of 9½ per cent. has volatile content of 36.8 per cent. The ammonia that should be obtained from that slack coal by our direct process is 27.8 pounds sulphate. The furnace fuel is 13.27 per cent. which is also stated as combustible free from ash and water amounting to 11.77 per cent.

It would be interesting to have an explanation of why in July the highest yield of gas was obtained and also the highest candle-power. The coal weights were taken from shipping weights and below it is stated that adjustments were necessary to charge off discrepancies in the coal stock. It would appear that shipping weights are not authentic enough to use for published results. I should like to ask if there are any carbon troubles with the Manchester retorts, also how the breeze is handled. With these vertical retorts I understand there is a charge of fifty or sixty pounds of breeze dropped into the retort before the coal is dropped in. That goes into the mouthpiece and when the charge is dropped that breeze mixed with tar is dropped out with the coke. I would like to know what means are taken to separate that breeze and tar from the coke so as not to deteriorate the quality of the coke.

Mr. Henry L. Doherty: I should like to call attention to one point and that is the fact that it is a very easy matter to discuss the results obtained in these various carbonizing systems and yet never get anywhere because we talk about cubic feet of gas in one case and candle-power and pounds of tar in another and we say nothing about what that tar contains. Now it is my belief that instead of being a difference in the results secured, it is a difference in the division of the products; that is, in some cases what would go to your gas goes to your tar, so that you get so many gallons

of tar without showing the nature of that tar and how much it contains in the way of illuminants, so it does not give you any basis on which to compare. I went away this summer on a vacation. While I was away I dropped in on a meeting of the British Institution of Gas Engineers, and they had a very animated discussion in the convention hall and a great many more animated discussions outside of the convention hall. The bone of contention between the various debaters might have often been settled by a standard method of determining the results obtained by carbonization. And while ordinarily the man who suggests a committee has to engineer it and do the work on it—I cannot do that, but I think the first thing that this Gas Institute should do is to appoint a committee to standardize our methods of testing for carbonization, because if we do not do that we shall never be able to reach a conclusion. For instance, Mr. Fulweiler called attention to the results obtained in candle-power at Manchester, which is probably due to the polymerization of the products in the top of the retort, and what ordinarily would go to the tar in the form of illuminants is given to the gas instead of the tar. It is not only an ordinary distillation process of a fixing process, but also polymerizes it so that it would ordinarily be so heavy that it would be liquid and become gaseous at ordinary pressures and temperatures.

While I am on my feet I want to call attention to one or two interesting things that I saw abroad. I noticed in one gas works where they were using outside generators—and they were doing that primarily to economize on labor—that it would have been a very easy matter for them to reduce their fuel cost enough to have completely paid their labor bills. That is they were spending more for furnace fuel than would have been necessary by the best practice to an extent equal to the full cost of their labor. The results secured in Europe by almost any system of carbonization to-day have brought the labor cost to a very low figure, so that the important cost now becomes the fuel cost. On the other hand

the labor costs as given in the various reports are somewhat misleading. I was in one retort house where one man apparently was doing all of the work in the manufacture of 750,000 cubic feet of gas. Outside there were two men to take care of the coke coming from the retorts; two other men outside were engaged in picking over the furnace fuel to recover the carbon. They were trying to reduce their furnace difficulties by the use of a large amount of water and steam, and the result was a large amount of fuel passed through without burning, and to recover that fuel they were picking it over. It was rather interesting to see two men picking fuel from a retort house that was run by one man. A great many of the high economies secured in Europe in every direction are secured not as commercial economies but as technical economies, while in America we strive more for commercial economy, and I think that nearly all of the reports they make over there, while they are intended to be strictly honest, are made on a basis that you are not safe in accepting unless you investigate further, unless you are sure that you know all of the conditions. Now when they talk about the efficiency for instance of heating apparatus using gas for fuel, they take what is termed the net value of the gas, that is they deduct the heat of condensation of the water, and yet often you will see them working with some sort of a system that uses part of that heat of condensation and they only charge off to their apparatus the net value of the gas. In other words, they work with a method that would be capable of giving them more than 100 per cent. apparent efficiency. I have been really interested in the large production of gas which has apparently been secured in many coke oven processes from a very low volatile coke. As a rule, we do not stop to compare the character of the coal but we are in the habit of considering that it is only so many cubic feet per ton. Now, when you try to make a calculation to indicate the yield that we should get from a high and a low volatile coal, the yield that we get from the coke ovens is really quite remarkable and that is one of the things

that ought to be taken up in the standardization of the methods of determining the results of carbonization. I call attention to the fact that a great deal of the difference in results was due to the division of the products between the liquids and the gases, that is, between the gas and the tar. I might also call attention to the fact that it is not a very hard matter by poor methods of scrubbing and condensing to reduce the candle-power as much sometimes as two, three and four candles, and in one particular case that is not before this body for consideration the poor results on candle-power in a certain system are due entirely to the very poor system of scrubbing and condensing. The people who are exploiting that system apparently know nothing about scrubbing and condensing and are getting bad results in spite of the fact that they should get very good candle-power gas from the method of carbonization. The one thing I want to leave in your minds is the necessity of standardization of the methods in which we state the results of carbonization work.

CAPTAIN McKAY: I should like to add a few questions to those that have already been asked. At Detroit two years ago the ovens we saw there were well filled and the coal was exactly level, and I do not doubt that a large part of the successful results at Detroit can be ascribed to the care with which the coal is filled into the retorts. On the other hand, in the Manchester verticals there is four feet of heated retort purposely left unfilled with coal, in order to break up and fix the vapors; here is a marked difference in practice. I wish Mr. Blauvelt would state as to whether, above the line of the top of the coal in the coke oven, there is any heating flue in service giving additional heat to the gases after they have passed through the coke and are on their way to the take-off pipe.

Moreover, at Detroit the coal is crushed fine before being charged into the oven; on the other hand, in Manchester the lump coal gave good results, and when lumpy coal is broken fine in transit, their results fall off. The analysis of the coal as to the volatile constituents does not seem to give full infor-

mation, or information that is comparative one time with another. Mr. Blauvelt may have some information as to the variation in the values, so far as gas making is concerned, of the volatile components of the coal when freely mined, and the value of the volatile components (showing the same percentage) from coal that has been in storage for several months. Will Mr. Blauvelt state how many B. t. u. he will give to a pound of coke, that we may see how many B. t. u. are used to coke a ton of coal, under the producer system? And will he also state in the same form the total B. t. u. in the gas fuel used per ton of coal coked. And whether he anticipates, with these further experiments, a substantial reduction in the total B. t. u. used to coke the coal? Will Mr. Blauvelt give us some information as to differential pressures within and without the oven and flues at the different heights of the six high ovens? And also some information as to the temperatures that exist at the different levels of the six high ovens?

In relation to this remarkable market for domestic coke in Detroit, I should like to ask further whether the great stimulus given to the sales of domestic coke is due to effective advertising, or to some salient feature in the preparation of the coke? We market in Boston probably a larger tonnage of coke for domestic purposes, and our present thought in the matter is that the care with which the coke is prepared for the domestic consumer is of prime importance. Is the Detroit metallurgical coke dense, or of open cellular structure?

The President: The Chair dislikes exceedingly to interrupt this very interesting discussion but we have a program which we must complete because Prof. Bone's lecture which is this afternoon, and therefore I am going to ask the authors of these three papers to reply to what has been said and promise the Association that if we have any time left at the end of this session we will resume this discussion. I should like to hear from the authors of the papers now.

Mr. R. M. Searle: What right has this Institute to ask a

member to begin a useful work on an important subject, and read a paper unless we take time to properly discuss it? It seems to me foolish for us to send a large number of men to an annual meeting of this kind unless we can take time to properly digest a subject.

This one subject alone is worth all the convention costs and I think it is an outrage that we should leave it half digested and I protest.

THE PRESIDENT: Gentlemen, we have between now and twelve-thirty a very carefully prepared paper by Mr. Bond; we have a very important matter in the report of the Calorimetry Committee; we have a very important report on Thermal Value and Candle-Power. Now, we also have two committees, one on the next place of meeting and a very unimportant one on the President's address, which cannot take more than two or three minutes. If this Association wants to cut out the last half of that program, as far as the President is concerned, you could not please him better. This is the most interesting discussion I have heard, but the rest of the program cannot be compressed into ten minutes time, and we cannot interefere with Prof. Bone's lecture this afternoon, and I do not think many of us want to miss dinner. I should be very glad to entertain a motion to the contrary, but unless such a motion is made I am going to request the authors of the papers to answer what has been said and then go on with the program, but if Mr. Searle wants to make a motion to the contrary I will put the motion.

MR. SEARLE: I will make such a motion.

The motion was seconded.

THE PRESIDENT: It has been moved and seconded to continue the present discussion, which will involve cutting out the program that is officially printed for the rest of this session. All those in favor of that motion signify by saying aye.

MR. E. G. PRATT: I offer an amendment that the conduct of the meeting be left in the hands of the President.

THE PRESIDENT: That is not necessary. I am glad to have discussion from the floor. I want every member to know that he can attack my conduct as Chairman without offending me personally.

THE PRESIDENT: Gentlemen, the motion is before you. Shall we go on with the discussion and cut out the rest of the program? Those in favor of Mr. Searle's motion, which is to continue this discussion, signify by saying aye. (Ayes.) Contrary, no. (Noes.) The noes seem to have it. Does any one ask for a division? (No response.) The noes have it and the authors of the papers will close the discussion. Mr. Miller, we will be glad to hear from you.

MR. SEARLE: I should like to rise to a point of order, which is that I am not attacking what we are doing, but it is the system of doing it. I make the suggestion for future meetings.

THE PRESIDENT: I hope it will be remedied next year, Mr. Searle. We will hear now from the authors of the papers.

MR. WARREN S. BLAUVELT: Answering the question as to whether the leakage from retort ovens is due to the porosity of the material or to leaks at the joints—it may come from both causes. With a varying pressure on the retort, sometimes below and sometimes above the pressure in the oven heating flues, the leaks will not be stopped by deposited carbon. When heating our gas ovens before charging, we operated for a time with the gas in the heating flues above atmospheric pressure, and with an insufficient supply of oxygen for complete combustion in certain flues. On looking into the oven chamber a film of carbon monoxide flame was plainly visible covering the entire surface of these flues. As this flame was not particularly in evidence at the masonry joints, it was obvious that the gas leaked through the refractory material as well as through the joints. Now with a uniform pressure control which keeps the pressure in the oven slightly above the atmospheric pressure, after about five charges, all the leaks both through the material itself and through the joints

are closed. In order to secure this result it is important that there should be a nearly perfect control of the gas pressure within the ovens. To be fortified on this point I have brought with me several charts showing that the variation of pressure on the hydraulic mains was only about one-half a millimeter of kerosene. This enables us to get a gas of remarkable uniformity, low in nitrogen and CO_2. I have with me a table containing all the gas analyses made in December, 1910; most of the samples were taken at the stations of the Detroit City Gas Company.

ENRICHED GAS ANALYSES, DECEMBER, 1910.

Date	Place	C_6H_6	CO_2	C_2H_4	O_2	CO	H_2	CH_4	N. by diff.
1	Delray	1.4	1.1	3.3	0.7	4.2	50.6	35.0	3.7
1	Delray	1.7	1.2	3.0	0.9	4.7	50.2	34.7	3.6
8	Ovens	1.5	1.6	3.7	0.6	4.6	50.2	35.9	1.9
8	Delray	1.7	1.8	3.9	0.4	4.4	49.0	35.8	3.0
8	Ovens	1.5	1.7	3.5	0.6	4.6	47.7	37.4	3.0
8	Delray	1.5	1.8	3.8	0.5	4.6	49.1	35.0	3.7
21	Sta. A	1.2	1.4	4.0	0.9	4.6	49.6	35.0	3.3
21	Sta. A	1.4	1.5	3.8	0.7	4.5	50.6	34.5	3.0
21	Delray	1.5	1.5	3.9	0.8	4.5	49.8	35.8	2.2
21	Delray	1.3	1.5	3.8	0.5	4.7	50.0	35.3	2.9
29	Delray	1.2	1.5	3.8	0.8	4.4	50.7	34.7	2.9
29	Delray	1.2	1.9	3.4	0.8	4.7	56.6	35.6	2.0
29	Sta. A	1.2	1.5	3.5	0.9	4.5	50.8	33.2	4.4
29	Sta. A	1.2	1.6	3.4	0.9	4.6	48.9	35.0	3.8

FUEL GAS ANALYSES, DECEMBER, 1910,

1	Ovens	0.2	1.3	2.0	0.5	4.8	50.7	38.1	2.4
8	Ovens	0.2	1.2	2.2	0.3	4.5	55.6	31.2	4.8
22	Ovens	0.2	1.2	2.7	0.6	4.7	57.3	29.4	3.9

To illustrate the reliability of the control of the calorific power of the gas as a result of the uniform hydraulic main pressure combined with the method of gas separation employed, and also to illustrate the satisfactory results obtained with benzol enrichment during the winter, I will, with your per-

mission, present a table showing the record of tests to determine the calorific value and the illuminating power of the gas delivered December 16 to 31, 1910. In explanation of this table I would say that the gas is purified at Delray Station about one-third of a mile from the ovens; Station A is about two miles from Delray Station.

LOG OF GAS OPERATION, DECEMBER 17-31, 1910.

Date	B.t.u's. per cu. ft.		Avge.	Avge.	Candle-power line tests		Sample holders
Dec.	Req'd	Del'd	Delray	Req'd	Station A	Delray	Station A
16	640	646	18.35	18.00	18.90	18.93	18.81
17	640	651	18.18	18.00	no test	18.38	18.86
18	640	647	18.23	18.00	19.17	18.40	19.18
19	633	639	17.14	16.87	17.55	17.38	17.57
20	607	624	15.22	15.17	16.38	16.10	16.08
21	619	626	15.56	15.94	16.14	15.93	16.40
22	612	618	15.52	15.50	15.89	15.68	15.96
23	606	618	15.13	15.08	16.07	15.26	15.81
24	605	617	14.93	15.00	16.05	16.58	16.19
25	605	611	15.14	15.00	15.52	15.60	14.76
26	614	616	14.71	15.58	17.47	15.12	14.94
27	605	603	14.13	14.12	15.55	14.38	13.71
28	611	620	14.95	14.75	15.04	15.55	15.37
29	607	615	14.87	15.12	14.65	15.20	14.51
30	634	632	17.06	17.17	17.64	17.24	16.82
31	640	644	18.63	18.71	18.71	18.62	19.17

One of the questions asked indicated that the questioner thought that we use a bubbling hydraulic main. With a bubbling main we found it impossible to secure the desired pressure control.

With regard to the washing of the gas to remove the condensible hydrocarbons, I should have stated more clearly that those hydrocarbon vapors which are condensible under the most severe conditions of temperature and pressure to which the gas is to be subjected are removed. The loss of candle-power due to the oil washer is generally less than one candle

and is caused largely by the elimination of naphthalene, toluol and zylol. As benzolized oil is in this washer comparatively little benzine is absorbed from the gas.

The table of results obtained last December when cold weather prevailed much of the time shows that there was practically no loss in candle-power between our works and the station of the Detroit City Gas Company. I may add that the line through which the gas is delivered, formerly a natural gas main, is laid very near the surface so that the gas is sometimes cooled to below 32°F. in cold weather when there is no snow on the ground.

With regard to the rate of carbonization as affecting the quality of the coke, I do not wish to be understood as speaking with final authority on this point, but the results with the coal which we have used at Detroit indicate that different rates of carbonization are required according to the use to which the coke is to be put. Foundry coke requirements are that the coke shall be relatively dense, that the pieces shall be large and blocky. To get that result with certain kinds of coals, carbonization must proceed at a relatively low temperature as compared with the temperature which experience on the same coals indicates gives the best furnace coke. With blast furnace coke it is better to have smaller pieces of a uniform size and of a well developed cell structure with thick heavy walls, so that the smaller pieces into which the coke breaks are mechanically strong. These results are obtained best when the coke is made at a very high temperature. In making foundry coke we have secured the best results with temperatures which will give a coke, with the volatile matter below 1½ per cent., when coking at the rate of 20 hours in a 16½ inch wide oven. When making furnace coke I am of the opinion that the best results are obtained when coking in a much shorter time, probably 15½ to 16 hours in an oven of the same width. With the regenerator ovens which we operated similar to those that we expect to get into operation in a few weeks, we were able to coke without any difficulty in

$14\frac{1}{2}$ hours. The coke so made, however, was relatively small and would have been absolutely unfitted for foundry coke requirements.

The question of a suitable location of a coke oven plant has come up and the question of the sales of domestic coke. I would answer the question in regard to whether a market has been obtained by advertising or by preparation, by saying distinctly, by preparation. When the Detroit plant was built the Gas Company was a very large advertiser of coke for domestic fuel. A tremendous increase in the production of coke in the Detroit district has resulted in the elimination of advertising expense for the sale of domestic coke both by the Detroit City Gas Company and by ourselves. Coke in former years was an unfortunate residual which had to be moved at the prices it would bring. At certain seasons there were enormous stocks and a strenuous campaign of advertising and selling was necessary; then in January or February, when people wished to reorder coke, there was none to be had, and the next fall the same campaign had to be repeated. As a result, coke sold at a price far below its true value as compared with anthracite. Advertising expenses were heavy; new customers had to be obtained every year. Now, since through the whole district coke can always be purchased, one satisfied customer will say to his neighbor, "I saved $20.00 in my fuel bill last year by the use of coke," and the good work spreads itself. It is quite important, however, to have the coke very well prepared. At the present time we are following a practice of rescreening the coke from the bins. The amount of fine stuff removed is very small, but as coke is handled there is a tendency for the breeze to get into one place in the pile. The result is that the customer who gets the leavings of the pile gets a large percentage of breeze and is dissatisfied. The removal of 500 pounds of breeze from a thirty ton car of coke makes all the difference in the world in the satisfaction of a customer.

With regard to the question of the effect of the gas being

exposed to a high temperature after it has come off from a retort, there is a difference in practice which is based on sound reasoning. The horizontal flue retort oven possesses certain very distinct advantages for controlling the secondary reactions which take place. Captain McKay asked a question about the relative levels of the top of the heating flue and the top of the charges. By the ordinary method of charging and leveling a retort oven the level of the charge on top is always at a fixed elevation, depending upon the location of the leveling ram. With the horizontal flue oven it is possible to have the top flue at any temperature that may be required. It is also possible in the design, to vary the location of the top horizontal flue, relative to the level of the top of the charge of coal, as may be desired according to the quality of coke that is to be made at the particular plant. In England and on the Continent the plan is generally followed of leveling the charge of coal at an elevation from six to ten inches above the top of the top flue, so that the carbonization of the coal in the top of the oven is carried on very largely by the heat which ascends from the lower and hotter portions of the oven. In the manufacture of foundry coke this is probably a distinct advantage because the top portion of the charge of coke is rejected in loading foundry coke. The low top temperatures increase the yield of ammonia very materially, making a difference of as much as two pounds and a half of sulphate per ton of dry coal in the yield. Also naphthalene trouble is unknown where those low temperatures prevail. Benzol yields are high and the tar is lower in free carbon. In making blast furnace coke, however, where the entire charge of coke is delivered to the furnace, it is important that every portion of the charge of coke as it comes from the oven should be almost exactly of the same temperature, indicating that the carbonization process has proceeded at a uniform rate from the walls to the center, and that the cell structure developed in the top of the charge shall be as near as possible the same as the cell structure developed lower down; consequently in a plant designed primarily for

the manufacture of furnace coke, it is, I believe, the best practice with the horizontal flue oven to have the charge of coal leveled at a point not more than one or two inches above the top heating flue. It is also important to carry temperatures in the top flue practically the same as the temperatures in the other heating flues.

With regard to the question of moisture in the coal. On a year's operation the moisture in the coal as received at Detroit varies between the limits of three and four per cent. The average is approximately three and one-half per cent.

With regard to the determination of the total quantity of fuel gas, I will say that we measure the gas that goes to each individual block of ovens with Venturi meters. These have been checked by setting them up in series with the station meters belonging to the Detroit City Gas Company. We have found that the difference between the amount of gas as calculated from the Venturi meters compared with the amount recorded on the station meters on different tests to vary from fourteen-one hundredths of one per cent. to sixty-five-one hundredths of one per cent. I am not quite sure which is the more accurate.

It was noted by some one that the total gas given in the table in my paper was the same with all the different types of ovens. That was done purposely. I believe that all of our experience leads us to the conclusion that with the same coal and with the same coking time, it does not make any difference which type of oven we used. These results were the average results obtained from several months' operation. From day to day the results varied considerably, the total gas varying from about 10,400 up to 11,300 cubic feet per net ton of 2,000 pounds of dry coal. That difference is due almost entirely to the quality of coal charged. There is a great difference in the yield of gas and the other by-products as to whether the coal is freshly mined or whether it has been in stock. It is my impression that with our coal the per cent. of volatile increases for a short time after the coals are put into stock. This in-

crease is probably due to partial oxidation. Hence the total yield of gas is always less in stock pile coal than in coal which has come direct from the mine.

I wish to endorse most heartily Mr. Doherty's suggestion that a standard method of standardization tests should be furnished by a committee of the Gas Institute. If this were done it would simplify these discussions and it would not be necessary to take up so much time describing what the figures reported in these papers mean.

With regard to the question of recuperation *vs.* regeneration. We are not prepared to give out any figures on the results with our regenerator ovens. I think the gentleman who spoke of that probably drew a correct conclusion when he called attention to the fact that we were building additional ovens of that type. I am sure, however, that the use of recuperators *vs.* regenerators is purely a local question. The difference in the amount of surplus gas that will be available due to getting say six hundred degrees centigrade higher temperature for the air used for combustion with the use of regenerators is offset by the loss of steam that can be generated by the waste gas boilers. It is purely a question of the value of that gas which could be saved, as compared with the value of the steam which could otherwise be generated. In practice it is possible to get approximately the same thermal efficiency from the combined unit, boiler and oven, using recuperators, or ovens alone using regenerators.

I am unable to answer all of Captain McKay's questions offhand with regard to the differential pressures in the flues and in the ovens. In the ovens we aim to run with a pressure just above the atmosphere, say from a half a millimeter to a millimeter above the atmosphere; in the flues depending upon the method of operation there may be a difference from the top flue to the flue next to the chimneys of ten or twelve millimeters of kerosene.

In comparing the results by different methods of carbonization, it is I think very important that if any test is standardized

the volatile matter in the coal should be standardized. We all know that there are certain coals that carry thirty-five per cent. volatile matter from which the yield of gas will be less than from other coals that are only twenty-five per cent. volatile.

There is one thing that is quite readily appreciated when it comes to a comparison of the labor costs; the large unit is a great advantage over the small unit. I was comparing results recently with a friend who has charge of another plant where the ovens are practically twice the size of the ovens at Detroit. We found that our operating unit crew was almost exactly half the number of men employed at the other plant. So far as we are able to see the number of men making up an operating crew would not be increased in any particular if the oven capacity were doubled. Notwithstanding the fact that our plant employed only about fifty-five per cent. as many men in the operating crew, the other plant had a little lower labor charge per ton of coal due to the larger size of the ovens. Therefore it seems unquestioned that in comparison with other forms of retorts of smaller size, the large retort oven has an advantage which can hardly be overcome.

Mr. Carroll Miller: The difference in candle-power between the flat flame and the Argand is practically constant for a fixed candle-power in a flat flame, but the higher the candle-power the nearer the flat flame and the Argand approach each other.

I think there is no doubt that the empty space in the top of the retort increases the yield of gas. Our retorts are filled to within six inches of the mouthpiece. It is indicated that the yield is larger in Mr. Africa's case by the smaller yield of tar. Our yield of tar is a great deal higher than Mr. Africa's. I should like to ask Mr. Africa what are his average yields of tar and ammonia for the months for which he has given the results. He only gave these figures for the test.

The amount of coke per 100 pounds of coal carbonized used in a producer is usually higher in the case of a small grate area and shallow fire than when a large grate and deep fire is used.

For instance, in Worcester, only about six pounds per hour per square foot is burned. I should like to ask Mr. Africa how much he burns and the size of the grate as well as the depth of the fire, and the same from Mr. Blauvelt. The number of our men is ten altogether, five on each shift, and these men charge and discharge the retorts and clean the fires. The coal contains a good deal of slack and is crushed, so that the largest lump is two and one-half inches. The reason that our methods of sampling would give a smaller proportion of lumps in the sample is that when the edges of the chute that puts the coal into the bins approaches the edge of the hopper the larger lumps cannot get into the hopper.

We sell a good deal of coke for use in cupolas. We have never found that the sticking in the retort was due to any accumulation of carbon; in fact, just after the retort is scurfed, the charge very often sticks worse than just before. Would Mr. Africa please tell us the length of time the coal stays in the retort? There were a good many other questions asked in regard to breeze in the bottom of the retorts, etc. I do not remember whether they were asked of me or Mr. Africa, but possibly he can talk a little bit faster than I can, so to save time I will ask him to do the answering.

Mr. Africa: Mr. Miller answered the question about the difference in the standard burner. In regard to the amount of coal handled per man per day, as we have erected only two benches, we did not put in mechanical appliances for handling coal, so our coal handled per man per day is not quite so much as at Providence.

The quality of the coke. We have a branch of the American Locomotive Works located at Manchester. They have examined the coke and want to use it in their furnaces, but thus far we have had such a demand for domestic coke that we have been unable to supply them.

The coal used in the test was three-quarters screened coal, screened at the mine and shipped all rail. The ordinary coal is three-quarters screened coal at the mines and shipped by rail to

tidewater, loaded on to a vessel and unloaded from the vessel into the cars at Portsmouth, then dumped from the cars into our sheds, which breaks it up as fine as run of mine coal.

The three months' test was with the latter quality of coal. We have had no particular trouble with the carbon, that is, not more than you would have with ordinary horizontal retorts.

The amount of breeze used in each retort is from one-half to three-quarters of a bushel, forty to fifty pounds, which when mixed with the coke, crushed and screened, does not injure the quality of the coke.

The length of the charge is nine hours.

Mr. Miller suggested we did not give the tar and ammonia on the several months' tests. As we have some settings of horizontal retorts and it is necessary at times to run both at the same time, it is difficult to keep the tar and ammonia separate during a period of several months, but we were able to do it for several weeks during the test, as the horizontal benches were shut down.

If I have overlooked any of the questions, I would ask Mr. Fulweiler to answer them, as he had charge of the tests as recorded on page 503.

MR. FULWEILER: There are a couple of the questions that I have here, I may have missed some, but regarding the temperature in the benches, it is very much the same as the temperature recorded by Mr. Miller, but a little bit lower. In the combustion chamber the temperature runs around 2,500° F. and the temperature at the retorts is about 2,200° F. At the top where the waste gas goes into the recuperator, it is about 1,600° F. The actual temperature of the entering secondary air is somewhat higher; that runs about 1,800° F. This is due to the fact that we take our air down again to admit it to the combustion chamber, that is the auxiliary combustion chamber. and in passing down it takes up some little heat from the main combustion chamber.

Regarding the pressure in the retorts, I do not see that three

inches of water pressure is a serious matter as affecting the carbonization of the coal, and this is due to the fact that in the vertical retort we have a quite high column of coal and a very small periphery, so that the area for the escape of gas decreases very rapidly. When the coal is first charged there is nc excessive amount of pressure.

As to the character of the tar, I would say our tar has a gravity about 1.124, and about eight and one-twelfth per cent. of free carbon; that gives a corrected gravity for the pure hydrocarbons of about 1.087. The corrected coke would be about thirty per cent. of the tar. The twice dephlegmated distillate up to 170° in our tar shows 1.4 per cent. and its gravity 0.87—approximately that of benzol. In answer to another question. Our Manchester grate has about 22.5 square feet of surface and we burn from five to six pounds of fuel per square foot of grate surface per hour.

THE PRESIDENT: The chair will announce one ruling from which I feel sure there will be no dissent, and that is that these gentlemen who have prepared these papers have the hearty thanks of this Institute for them.

We have to give this platform to the pipe fitters pretty promptly. I want to leave every minute of time to the business that is to follow, so I am going to call now for the report of the committee on next place of meeting.

REPORT OF COMMITTEE ON NEXT PLACE OF MEETING.

MR. E. G. PRATT: Mr. President and Gentlemen: The committee on next place of meeting unanimously recommends Atlantic City. (Applause.)

THE PRESIDENT: You have heard the report. Does the convention concur in the report of the committee?

MR. GARTLEY: I so move.

The motion was seconded.

THE PRESIDENT: It is moved that the convention concur in the committee's report. Those in favor will signify by say-

ing aye (Ayes). Contrary no. (No response.) The motion is carried.

I will now call for the report of the committee on the President's address.

Report of Committee on President's Address.

This committee reported by its chairman, Mr. Lathrop, as follows:

Gentlemen: The President's address, as was expected, is full of good thoughts, and while no recommendations are contained in it that require any action of the Institute, still there are a number of suggestions which should be given especial attention.

He points out the fact that control by state commissions need not have all the disadvantages frequently attributed to it, if the commission be composed of reasonable men of sufficient business experience to understand the problems which confront the business.

All of us have undoubtedly been disturbed by the growth of awards in damage cases, and will welcome any proper safeguard which can be put around our affairs which will put public service corporations on a par with other lines of business.

The President brings out very forcibly the good work which has been done by this Institute by showing, among other things, that but for the Institute there would be practically no text books on American Gas Engineering.

The benefits of coöperation between companies, not only in the same state but in other states, is well brought out.

Whether the Institute should attempt original investigation or not or should leave it to others to determine, should be given proper consideration.

We are so accustomed to look, or perhaps hope, for large growth in our business that it seems almost revolutionary to suggest that there is no necessity or good to be accomplished by increasing the treasury balance and membership lists of the Institute by taking in new members, at the same time a body

such as this Institute gets little or no benefits from an inactive, disinterested membership.

ALANSON P. LATHROP,
JAMES W. DUNBAR,
Committee.

THE PRESIDENT: The President thanks the committee for their tender treatment. The report will be received and filed as usual. The next business is the reading of a paper on "A Survey of American Gas Photometry," by Mr. C. O. Bond.

MR. C. O. BOND: It is hardly right to call this a Survey of American Gas Photometry; it is rather a resume of things that have been left undone on the subject of photometry. I wish very briefly to state that the paper is divided into three parts. We have been entitled to representation in the International Photometric Commission. Representatives have been appointed. There have been three meetings of that commission, but we have not yet had a representative present. I therefore have put in the first appendix a short account of those three meetings.

A SURVEY OF AMERICAN GAS PHOTOMETRY.

In response to a letter from the Chairman of the Technical Committee asking for a paper on photometry, with the inference that information was desired as to the work of the International Photometric Committee, which met in Zurich for its third session in July last, I have prepared the following paper in three parts:

A. Remarks as to the International Committee on Photometry.

B. Collecting the "unfinished business" that has been left from other papers on Gas Photometry before this Institute.

C. The present status of Gas Photometry in the United States.

(A) THE INTERNATIONAL COMMITTEE ON PHOTOMETRY.

A subject of such importance merits recognition well beyond the limits of a personal contribution. It is unfortunate that our American delegates have not been able to attend

the sessions of the International Photometric Committee, for through their reports this Institute would have kept in closer touch with foreign thought on matters concerning our industry.

The importance of the subject matters dealt with and the high standing of the engineers and scientists comprising the International Committee would make such reports valuable indeed to the members of this Institute.

To instance several of these papers there may be mentioned one by Mr. Charles Carpenter, detailing the development of the Metropolitan No. 2 burner; the classical researches by E. Sainte-Claire Deville on the relation between heating value and luminosity of gas and the three National Laboratory comparisons of Standards of Light, to which credit must be given for stimulating the investigations which have led up to the proposed International Candle.

In Appendix I, will be found a brief account of the formation and work of the Committee thus far,—sufficient, I think, to warrant instructions to our new delegates to prepare a full report on the three Zurich sessions for insertion as an appendix in the Institute Proceedings. I hope such a motion will prevail.

Through an increase in the size of the International Committee, America is now entitled to three delegates, with the recommendation that they be appointed early in order to permit of prompt organization for research and other work. A yearly progress report from these delegates would be helpful.

(B) Unfinished Business.

I find in reviewing the five volumes of the Institute Proceedings that communications having a bearing on photometry have been made by the following gentlemen:

Messrs. Doty, Lansingh, Gartley, Hyde, Litle, Macbeth, Bond and Bradley.

While much of a definite character has been accomplished by, or as a result of, these communications, yet there are at least two unfinished subjects of such importance as to warrant

again calling the attention of the Institute to them. These subjects are:

(1) A discussion of the calorific test and the photometric test as a criterion of gas quality.

(2) Discussion upon a standard test burner.

(1) Calorific or Photometric Test?

As stated by President Bradley in his address at the 1910 Convention this is perhaps the question of greatest importance now before the gas industry.

At the beginning of the industry, (which was in England) gas was supplied for the purpose of giving light only. The criterion of its value was the sufficiency of illumination received from it, as compared with the illuminant which it tended to supplant—namely, candles. It was found that a flame of convenient usable size consumed about five cubic feet of gas per hour, which rate for testing purposes was arbitrarily fixed. The style of burner in common use was adopted also for a test burner; and thus the method of test became such that in effect the consumer was sold the equivalent illumination which he had earlier paid for. This was much like selling light,—it was rated in *candle*-power. It can be seen by this method, as the efficiency of the light transforming devices increases, that for an equal illumination the gas sold decreases.

This decrease of consumption for equal illumination has several times been experienced as there have come into use the Argand burner, the regenerative burner and the incandescent burner.

That there has not been a consequent decrease in gas consumption for lighting was due to the fact that more lights and lights of higher candle-power were used, because the average consumer's premises were insufficiently lighted.

As the days have passed this dearth of light has been more and more corrected. We now know when the illumination is sufficient and we stop there. The cry to conserve natural resources makes it right that we should stop there. So that it can not much longer be hoped that the loss of consumption

through rising efficiency in the *light* transformer will be offset by persuading the consumer to use more light that he really needs.

It is well to recall at this point that during the transition in England from self-luminous to incandescent lamps for the

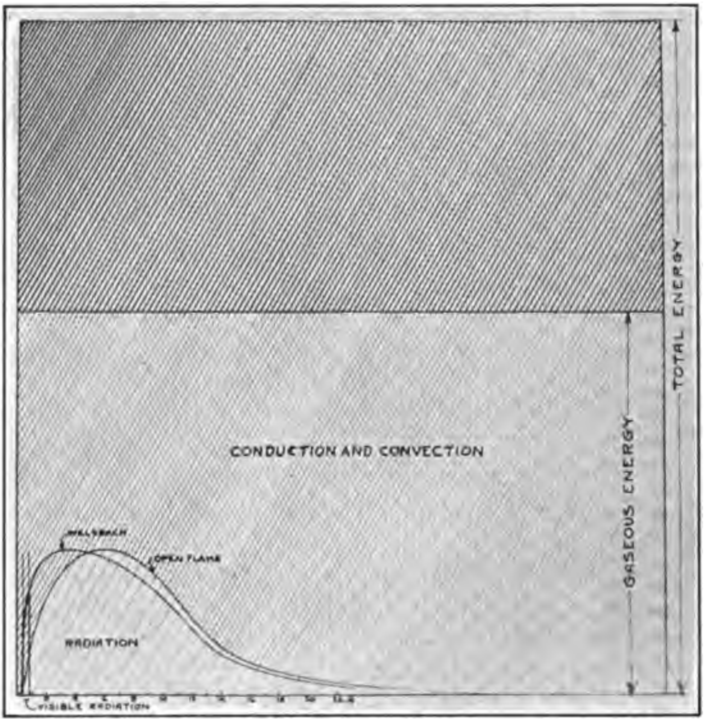


Fig. 1.

several years preceding 1907, the gas output was stationary, and even in some towns decreased.

Reference may be made also to Bulletin No. 9 of the National Electric Lamp Association, by the Chief Engineer, Mr. S. E. Doane, published 7-30-'09, entitled "The Conservation of our Natural Resources through the use of High Efficiency Lamps." He notes a similar reduction in electrical

energy output due to the advent of the tungsten lamp, but welcomes the conservation and sets about devising a way by which both the producer and consumer are benefited, utilizing the principle of "Fixed Charges for Fixed Expenses."

In order to indicate the progress made in bettering our *light*

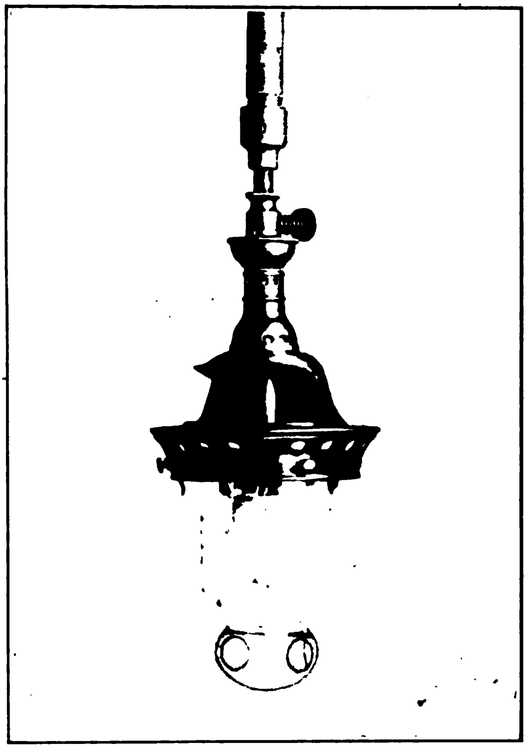


Fig. 2.

transformer, I give here diagrammatic curves, Fig. 1, showing in the minute white areas the proportions of the total gaseous energy which go to the production of radiation within the visible spectrum, (1) with a normal incandescent lamp and (2) with an open flame burner. The first is about 0.34 per cent. and the second 0.082 per cent.; for if all the energy of gaseous combustion should be converted into radiation within the visible

spectrum there would result about 106 lumens, or 8.5 mean spherical candle-power, per British thermal unit per hour.

The normal lamp mentioned has been chosen because of its common use throughout the country. It is shown in Fig. 2

Fig. 3.

and is the bare unit without accessories. The mantle used as a standard, Fig. 3, has the following characteristics:

Mesh per square inch	26 × 26
Projected luminous area	1.97 sq. in.
Total surface area	6.66 sq. in.
Volume	1.935 cu. in.
Weight per sq. in. luminous ash	0.0688 gram
Total weight luminous ash	0.46821 gram
Material	Artificial silk

The average efficiency of this lamp over the period from June 22 to August 26, 1911, was determined under the conditions below:

Number determinations	32
Gas used	Mixed, (coal and water)
B. t. u. average	646
Specific gravity average	0.674
Consumption average	3.40 cu. ft.
Pressure	2.5 in.
Liters water vapor per cu. meter dry air	15 to 28
Lumens per B. t. u. per hour, average	0.34
Lumens per B. t. u. per hour, least	0.313
Lumens per B. t. u. per hour, highest	0.355

On a single test made for temperatures the following results showed:

Volume free flame	2.128 cu. in.
Average temperature free flame	2979° F. (Abs.)
Average temperature mantle	2352° F. (Abs.)
B. t. u. per hour per 0.1 gram luminous ash	515

The open flame burner used was the 8 ft. E. H. lava tip.

Let us suppose that some impregnating fluid is discovered, or a temperature produced, which raises the best efficiency of mantle burners four times, or to, say, 2 per cent. What will be the result? If one-third of the present gas output is for lighting, then it would mean a reduction of gas output by about 25 per cent.; which would be a conservation to be proud of, but which would also effect a 25 per cent. reduction in receipts.

There will be, without any doubt whatever, a steady increase in the total lumen hours by the use of gas, but it is to be hoped also that there will be a rise in the pitiful luminous efficiency shown, even though it should reduce the gas consumption.

In the foregoing discussion the gas industry has been viewed chiefly from the standpoint of a furnisher of light, which it started out to be. If, on the other hand, our conception of the

gas industry is that it takes nature's energy in crude form and has for a primary aim to make the highest obtainable percentage of it available and instantly deliverable for use in a satisfactory gaseous form, and if our only aim is to determine how successfully this is done, then this energy conversion should be tested by a scientific instrument highly efficient, in order that we may accurately know the efficiency of our conversion from the original coal. The *Calorimeter*, which has an efficiency of 99.5 per cent., answers this requirement. The fact is, gas is valuable for heating, for power and for incandescent lighting in accordance with it calorific content, and if it were not for the fact that a portion of the gas supplied is still used in open flames, the Calorimeter would be, logically, the only instrument of test.

The energy in gas coal, through the use of vertical retorts and the by-product coke in water gas generators, is to-day about 58 per cent. recoverable as gaseous energy (though at a B. t. u. content per cu. ft. of about 450)—which is not a poor conversion. This gaseous energy when applied to a good commercial heating device averages 80 per cent. utilization; when applied to the production of power from 25 to 30 per cent., and when applied through the mantle to the production of light 1/3 of 1 per cent. From these figures it is easy to predict at the beginning of this century of conservation and efficiency the direction of the growth of output.

It was suggested that I write to several of the European countries and find the present attitude there towards the change from the photometric to the calorific test. I did so, and the results are shown in Appendix II.

As the International Photometric Committee, with delegates in attendance from these same countries and representing these same Gas Associations, met in Zurich in July 1911 and discussed this subject, their views will also be of interest.

Dr. Eitner (Germany) stated that the substitution of the calorific test would be effected gradually. They have begun to allow a gross calorific value of from 5,000 to 5,200 calories per cubic meter (531 to 553 gross B. t. u. per cubic foot),

the illuminating power being from 10 to 12 Hefners per 150 liters (9 to 10.8 candles per 5.3 cubic feet).

Dr. Colman (England) stated that the English Engineers were not opposed to the introduction of the calorific power test, but were opposed to a dual test.

M. Deville (France) strongly urged the replacing of the examination of illuminating power by that of calorific power. (It will be remembered that this substitution has been his concluding argument in his series of valuable papers before the Committee.)

Dr. Strache (Austria) stated that in his country they had begun to accept the gross calorific power. He proposed that the International Photometric Committee recognize the ***heat of combustion*** as a fundamental measurement and that the illuminating power remain outside the resolutions, as the gas is used for lighting, heating and power.

Thereupon the President appointed a sub-committee to consider and report upon this question, the Committee consisting of Messrs. Deville (France), Eitner (Germany), Weiss (Switzerland) and Colman (England).

The Committee as a whole, however, expressed its opinion: "That having regard to the methods of employing gas at present in vogue, the determination of the illuminating power of gas flames has lost its significance, and that the determination of calorific power ought to take the place of the determination of illuminating power as the essential criterion of the value of gas."

(2) Standard Test Burner.

If the self-luminous flame horizontal candle-power of gas is to be retained in America as a method of test, it is high time that definite approval be given by this Institute to some form of test burner. We can well observe the action of the Canadian Gas Association in this matter.

It was thought desirable by that Association to place the testing of gases in Canada upon a uniform national basis. The Association Executive accordingly sent delegates to the

Government at Ottawa who conferred with the proper authorities and secured the sanction of the Government for the general use throughout Canada of the Metropolitan No. 2 burner. A similar result at Washington would seem to be possible if this Institute really desires to continue the photometric test and is ready to act.

In the discussion of a standard test burner we should remember, however, that thus far the horizontal candle-power

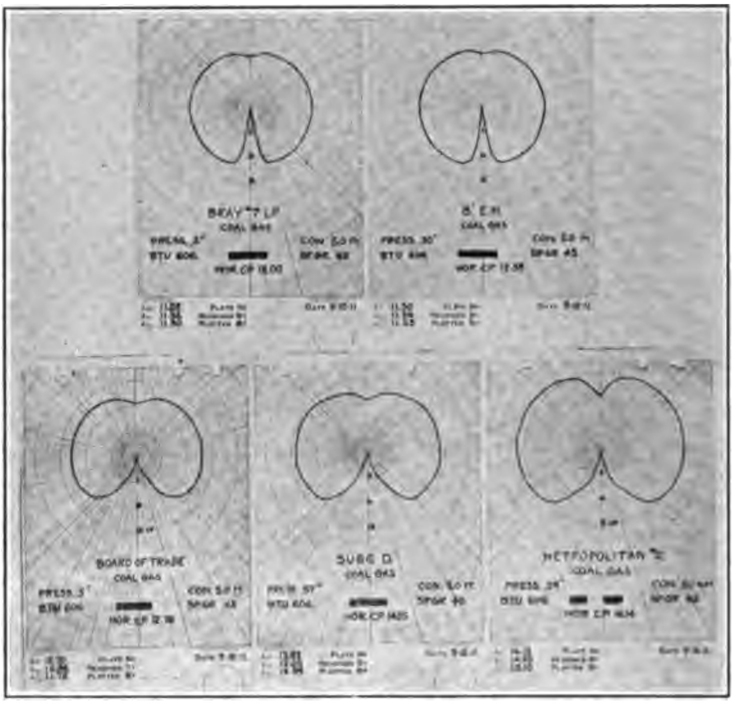


Fig. 4.

only has been used as a test, and the progressive design of the test burner has been, whether intentional or not, towards increased light in that plane. Had the efficiency of these burners been judged on the basis of the mean spherical candle-power, or had a rich gas been used during the testing out,

the design might have proceeded along somewhat different lines.

I give herewith distribution curves in a vertical plane of the light from several burners which are, or have been, used for testing purposes, together with the results in terms of M. S. C. P. (Figs. 4, 5, and 6).

It can be seen that the flat flame burner is almost a spherical

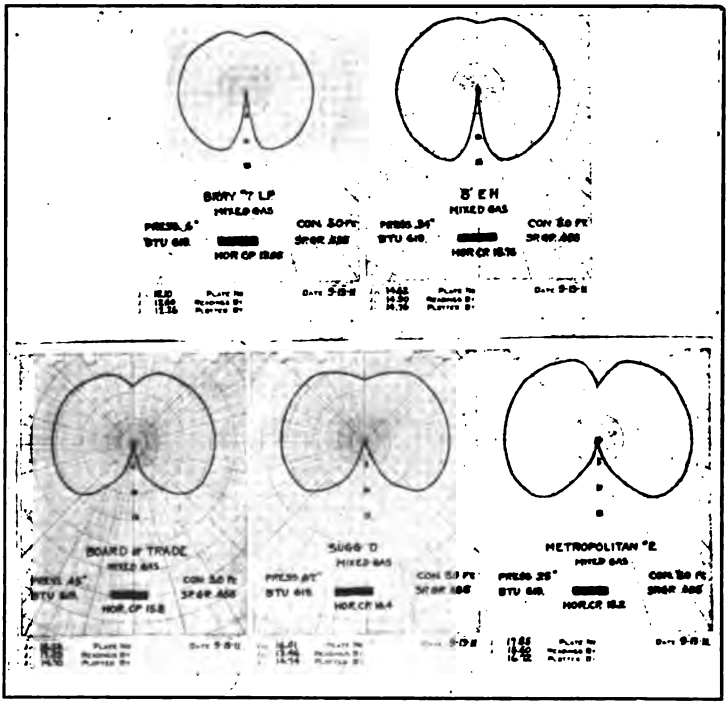


Fig. 5.

distributor of light, while the Argand flame, glass enclosed, elongated and locally raised in temperature, shows curves bulged somewhat more favorably for horizontal candle-power. The old flat flame test burner in the days when such burners were in practically exclusive use was, therefore, a fair criterion of the total flux of light.

The Carpenter burner, which is the most efficient of its class, particularly for coal gas, has an accurate control of the air supplied to the flame.

I quote from Mr. C. H. Stone, formerly of the New York State Public Service Commission:

"And now the question immediately arises, why should not this burner (Carpenter) be employed in every case, at least for

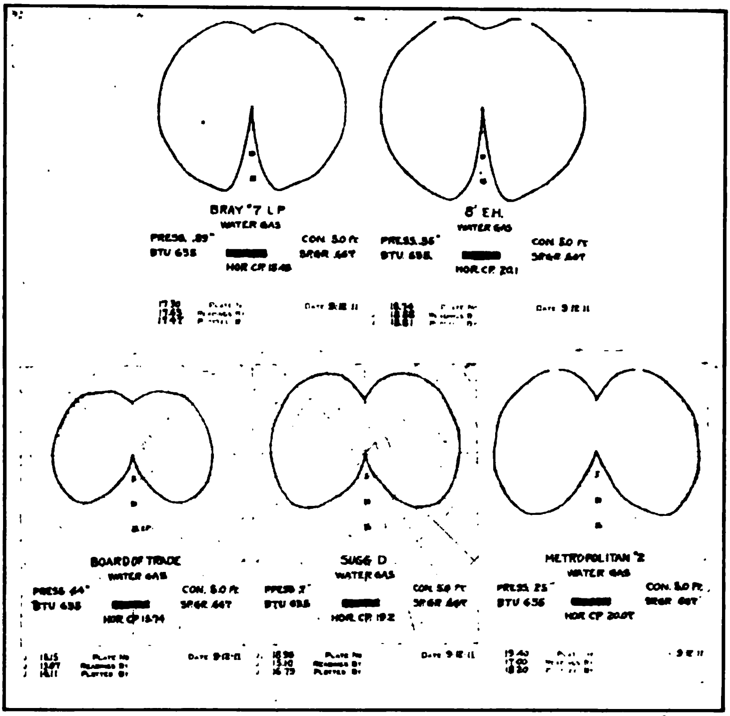


Fig. 6.

coal gas? The answer to this will be found in the consideration of two or three facts.

In Massachusetts the law requires that the gas shall be tested with the burner best adapted to it, which is at the same time practical for use by the consumer, and the authorities in that State have interpreted this to mean a burner which is not

only satisfactory in its mechanical details, but which in cost is within the reach of everyone. The price of the Metropolitan No. 2 burner is $25.00 and this would seem to place it beyond the reach of most consumers."

Right here is a fallacy in argument.

Since higher efficiency burners came in, there has been little thought, I take it, that the photometric test exactly measured the *quantity* of light which the consumer could get. The photometric test was regarded as a *qualitative* measure of the gas and the aim was to hold that *quality*, however measured. Such a measurement should be made, and the quality should be held through a scientific burner, whatever its cost.

You can pace off a plot of ground as a provisional measurement, but if a standard measurement is desired a surveyor's instrument and a steel tape are not too expensive to requisition for the purpose.

Nor would you for a test calorimeter use a commercial water heater.

It may be seen from Fig. 6 that the Carpenter burner for the richer gases gives no more light than the open flame. This is because its dimensions are not correct for the richer gases, it having been designed more particularly for coal gas.

Another standard test burner adaptable to gases from 16 to 26 candles should be specified therefore, for that range.

The points to be made are that the test burner adopted should be scientifically designed, exactly constructed and uniform the country over for similar gases. We should then be able to satisfactorily compare results, and the public could then be assured that year after year the photometric quality of their gas was unchanged.

While purely academic, and perhaps of little practical value, we still may speculate somewhat upon another form of test burner which would furnish a criterion not only of the actual light received by the consumer, but also of the total energy in the gas. Such a test burner would be *ideal* if it were 100 per cent. efficient in transforming gaseous energy into

light and it would be even *satisfactory* if the transforming efficiency simply remained constant.

Now, M. E. Sainte-Claire Deville's researches at Paris, repeated by and practically concurred in by Dr. Max Mayer, at Karlsruhe, claim a practical constancy of the ratio existing between the calorific value and the absolute incandescent value of luminous gases within the ranges of manufacture; and the calorific value represents the total energy in the gas.

The term "absolute" lighting value is the maximum horizontal candle-power per cubic foot per hour obtainable, the burner being supplied with dry air and saturated gas at the same temperature and pressure. It is no doubt true that a constant relation exists between this horizontal candle-power and the mean spherical candle-power.

Therefore, if the findings are true and we sought such a test, we might advocate for testing purposes an incandescent mantle burner of current high efficiency which fulfills the conditions above named for a *satisfactory* test burner, whose cost at the same time is within the reach of everyone and in using it we should determine the "absolute" mean spherical candle-power.

(C) Gas Photometry in the United States.

Whatever the future may have in store for gas companies we must recognize the fact that owing to existing franchises and contracts a very large proportion of the gas used in this country must still pass a photometric test. There must be photometrists connected with the companies capable of accurately making such tests and there must be well standardized apparatus with which they may work. As to light stanards we can say with more confidence to-day than ever before that the Pentane lamp is more likely to be a satisfactory primary flame standard than any other and that the Bureau of Standards at Washington has investigated thoroughly this lamp and they hold to-day a high opinion of its reliability.

Compared with its only serious rival in the field of Primary Flame Standards—the Hefner lamp—I find in the valuable

contribution of Messrs. Rosa and Crittenden, of the Bureau of Standards, (I. E. S. T., 1910) the following:

"Its higher candle-power, steadier flame and better color are very great advantages. As to reproducibility, a given Pentane lamp is more accurately reproducible than a Hefner lamp, when both are operated under correct conditions, but there is a greater difference among different Pentane lamps than among different Hefners."

And in the discussion Mr. Crittenden states his difficulty at first in operating a pentane lamp as satisfactorily as a Hefner, but adds: "but we have rather reversed our opinion. We are now glad to work with the Pentane and get away from the the Hefner."

The paper states further: "That the errors belonging to the *flame standards themselves* could be so small when measured in all kinds of weather, with a wide range of humidity and temperature, and considerable range of barometric pressure, with many resettings of the lamp, and over a period of some months, would not have been thought possible a year ago."

The correction formula now used by the Bureau for pentane lamp is:

$$I = I_n \left\} 1 - 0.00567 (e - 8) + 0.0006 (p - 760) \right\{$$

where I is the measured candle-power in International candles of the Pentane lamp under the atmospheric conditions; I_n is value of lamp under normal atmospheric conditions; e is liters of water vapor per cubic meter of dry air using the Assmann hygrometer; and p is barometric pressure in millimeters.

It is strongly recommended that Pentane lamps be evaluated and certified by the Bureau of Standards.

As to the other essentials for accurate photometric testing of gas, there is no text needed beyond what is already found in the American Gas Institute Proceedings. I believe, however, in this matter, there is an insufficient consulting of those volumes.

Partly owing to the influence of the Illuminating Engineer-

ing Society and partly owing to the epochal studies in radiation in recent years, the subject of photometry has grown out of its former modest and primitive domain.

We gas men have been acting all these years as if the photometer was simply one more piece of apparatus in the gas plant, like a condenser or a meter dial to be knocked about and damned if it did not produce what we expected. We have suddenly awakened to the fact that the real photometer is that precious possession—the human eye; and the intermediaries of mirrors, graduated arcs and test plates are being called into requisition by the eye in the fight for its rights. There is need. If this statement is doubted, call in the ocular testimony from the children of the public schools. It is for this reason that Societies for the Conservation of Vision are now being founded.

No doubt half the retinal harm is done under natural light, but that does not discharge our obligation to present blameless our quota of artificial light; for while the child both studies and recites by day, at night there is study only. And we furnish the light by which that study occurs.

Every manager of a gas industry should be as familiar with the term "foot-candle" as he long has been with the term "candle-feet." The "candle" in "candle-feet" has become habitual, and is to the gas manager simply part of his "yield" for the day—regarded as a physical, commercial quantity. The "candle" in the term "foot-candle" on the other hand, is the physiological measure of his service to those whom he essays to "light," and should involve the element of quality as well as quantity.

It seems plain then that in the gas industry the photometer must widen its area of usefulness, leave the gas works, and begin to travel. Conditions are reversed, and instead of the eye coming to *it*, the photometer must travel *for* or *with* the eye. There must be radial photometers, traveling over the surface of imaginary luminous spheres, or else surrounding them as does the integrating sphere; and there must be il-

luminometers, portable companions of the eye, by which the success or failure of a lighting installation may be measured and valued *in situ.*

Progressive gas undertakings are buying both kinds for use, and who will doubt that business will be easiest held and increased by those who call in the aid of science, and are prepared to give visible backing to their arguments. As of old, "Seeing is believing."

But this kind of photometry almost at once leaves behind the open gas flame; it becomes incandescent gas photometry, and new difficulties are presented. This was the cause of forming the International Photometric Committee. At least two most valuable conclusions have been reached through the efforts of that committee, as has been remarked earlier in this paper, (1) a common unit of light intensity, and (2) the establishment of a practical relation between the calorific and incandescent lighting value of gas. The first you may make use of by having your pentane lamps calibrated and certified in international candles at Washington. The second helps, because whatever artificial illuminating gas we use, we feel that by rating a lamp or a mantle in terms of "lumens per B. t. u. per hour" we have a tangible efficiency factor.

The other variables in incandescent gas photometry are so numerous that I will ask leave to make a separate paper on the subject to be presented at next year's meeting if it is desired, as this paper is sufficiently long.

The Chairman of the Technical Committee has no doubt been disappointed in his expectation of a highly technical treatment of the subject; but it seems to me that the gas industry to-day is not so much in need of mental "nuts-to-crack" (photometrically speaking), as it is in need of a general stirring of the rank and file with the determination to put into use the results already laid before them by the new photometry. There must be a deepening of the sense of moral obligation, so that when a consumer places his confidence in us and asks for *light* we shall requite him not with flickering flame nor blinding glare but the best we know, and placed with care.

APPENDIX I.

(Largely extracted from Proceedings of the Institution of Gas Engineers.)

The International Photometric Committee came into existence through the following proposal on the 4th of September, 1900, at the hands of the International Congress of the Gas Industry, which met that year in Paris, during the Universal Exhibition.

"The International Congress of the Gas Industry, considering that it is in the general and common interest of manufacturers, as well as consumers, of gas to have exact information on the illuminating power of burners used for incandescent lighting, RESOLVES, that an International Committee be appointed with the object of determining the rules to be followed in photometric observations on incandescent gas burners. The Congress executive is authorized to proceed with the organization of this Investigating Committee."

Accordingly it was decided to form the Committee with 18 members, four each from France, Germany and England, (due to their having national light standards) and one each from Austria, Belgium, United States, Holland, Italy and Switzerland.

The presidency of the committee was given to Monsieur Th. Vautier, of France, who still retains it. The organization of the committee had so far proceeded as to hold its first session in June, 1903, at Zurich, Switzerland, where was promulgated the program of its work in a list of seven questions, as follows:

(1) *Incandescence.*

Explain the existing ideas on the causes productive of illuminating power, obtained by means of incandescent gas, as well as the experiments upon which they are founded.

Summarize previous theories.

(2) *Secondary Standards.*

Give the principal figures found to be the value of the different secondary standards as between one another; set out

the methods of comparison used in each case. This investigation should include: the Carcel lamp, the Hefner lamp, the English ten-candle pentane lamp of Mr. Vernon Harcourt, the English pentane standard of one candle, the German Union paraffine candle, and the English spermaceti candle.

(3) *Photometric Rules.*

Rules to be observed in measuring the lighting power of incandescent gas burners, independently of standards of light and photometers. These rules must be applicable to different types of burners; but in order to be able to arrive at certain precise data, as a basis a burner may be taken consuming about 110 liters (3.885 cubic feet) at a pressure of 40 mm. (1.575 inches); this is, moreover, one of the most generally used burners. Among the rules to be laid down, we will mention those concerning the following points:—

(a) Regularity in combustion of the burner without mantle, but provided with chimney; dimensions; form of test chimney.

(*b*) Regulation of the ejectors for the agreed upon volume of gas (110 liters, or 3.885 cubic feet) at the given pressure (40 mm. or 1.575 inches).

(*c*) Duration of the combustion of the mantle *before the first,* duration of combustion before every other test.

(*d*) In how many azimuths will the measure of the horizontal illuminating power be made? How many photometric points at least will be made in each azimuth? (Either before or after reversing of the photometer, in cases where the instruments allow of this being done.)

Only the points which do not differ more than...... will be converged to the average.

(*e*) Indicate the calorific power and the number of candles or the standard of the gas used. (This information is, of course, subject to the results of examination into the fourth question.)

(*f*) Need of the adoption of an auxiliary standard in photometric work; measure its value in working with the

usual secondary standard, at the beginning and at the end of the experiment; minimum agreement allowed between these two measurements.

(*g*) Measurement of the variation in the lighting power with the duration of the lighting of the mantle. It will follow from the comparison of the lighting power taken, for example, at the hours of zero, ten............three hundred.

(*h*) Comparison of mantles of the same kind, but from different manufacturers; for this, account will have to be taken of the results found on examination of the fifth question.

It is requested that other points that it may be thought useful to have settled, as well as propositions to be made in this connection, will be notified.

(4) *Calorific Power of Coal Gas.*

Experimental researches as to the influence of the calorific power of coal gas on the lighting power of incandescent burners.

Deduce, if needs be, from the preceding experiments, the solution of the following question:—

When the lighting power of a burner supplied with gas of a known calorific power has been ascertained, how. by calculation, can the lighting power be found which this burner would give with a gas of different calorific power, taken as of normal power.

This correction would have for its object making photometric results, obtained with gas of varying calorific power, comparable as between themselves.

(5) *Standard Type of Burner.*

Experimental researches with a view to obtain a burner fulfilling the necessary conditions to constitute a standard type of burner to allow comparisons between mantles of different origins, but of the same kind; corresponding, for example, to an hourly consumption of about 110 liters (3.885 cubic feet) at a pressure of 40 mm. (1.575 inches).

Standard types of burners for higher and lower consumptions.

(6) *Mantles.*

(*a*) Different elements forming the mantle; their influence on the quality of the mantle.

This working aims at various subjects which can be treated as distinct investigations as regards, for example, the nature of the material forming the mantle, its microscopic examination, the deformation or shrinking of the mantle, resistance to mechanical strains, the causes in the variation in the lighting power with the duration of the lighting, the strengthening of certain parts, and, in general, the different modifications which have been recently noticed or introduced in the manufacture, on account of their beneficial effect on the durability, lighting effect, or any other quality of the mantle.

Some of the characteristics of the mantles, covered or not by paragraphs (*a*), are capable of being measured, and some of them would act as a check on certain qualities of the mantle, either in the course of its manufacture, or on its delivery; it is to make allowance for this point of view that we add the following question:

(*b*) Different tests applicable to mantles, with the object of ascertaining their properties independently of the photometric point of view, methods of measurement; stamping apparatus.

(7) *Standardization of Screw Threads.*

Standardization of screw threads of different types of fittings placed in consumers' houses for the distribution and use of gas.

(First Session)

The British Report of the Transactions and minutes of this first session, as prepared under the authority of the Council of the Institution of Gas Engineers, filled 71 pages of their Transactions. Twenty-two pages were devoted to the minutes and forty-two pages to the six communications as follows:

Dr. H. Bunte, of Karlsruhe: "Technical Standards of Light."

E. Sainte-Claire Deville, of Paris: "Variations in the Lighting Power in the Incandescent Burner of Combustible Gases."

Charles Carpenter, of London: "An Improved Photometer for Testing the Values of Ordinary and High-power Burners."

M. Bohm, of Turin: "A Method of Determining the Luminous Intensity of Incandescent Burners."

Th. Vautier, of Lyons: "Measuring the Toughness of Incandescent Gas Mantles."

M. J. Payet, "Note on the Standardization of Screw-Threads for Apparatus for Gas Consumption."

The recommendations resulting from the very interesting first session of this committee may be summed up as follows:

1. That in photometric tests on incandescent gas burners the calorific power of the gas be ascertained at the same time as its lighting power and that the gas should be described; as for instance, coal gas, water gas (carburetted or not), or mixed gas, with the proportions of each in the mixture, and if water gas what type of apparatus produced it.

2. When publishing the results of measurements experimenters are requested to give the calorific power in calories (kilogramme-degree) per cubic meter of gas at constant pressure, water as steam as zero degrees centigrade and 76 centimeters of mercury and to indicate the calorimeter used.

The committee takes note of and thanks M. Deville for his research as to the relation between lighting power by incandescence and calorific power of combustible gases and requested a continuation of this research by experimenters in other countries.

3. The committee recommended the provisional adoption of the relation between light standards given in Dr. Bunte's Table No. 2, which was (using the English candle as a unit):—

English candle = 1.
German candle = 1.05.
Hefner = 0.877.
Harcourt wick lamp = 1.03.
Harcourt ten-candle lamp = 10.00.
Carcel lamp = 9.53.

Further work was outlined as follows:

To eontinue the research as to the relationship between calorific power and incandescent lighting power of combustible gases; to urge upon delegates from different countries to furnish descriptions of the methods used in their respective countries for the practical photometry of incandescent gas burners; the continuation of the investigations of methods for comparing lights of different colors; the authorizing of separate tests in Germany, England and France as to the relative values of the standards of lights in these countries; and the authorizing of a subcommittee to deal with the standardization of screw-threads.

(Second Session)

The second session was held at Zurich in July, 1907.

The English report of this session filled 110 pages, illustrated. There were 15 pages of minutes and 95 pages containing 16 communications, as follows:

James W. Helps, of Croydon: "Methods for Measuring the Light of Incandescent Burners in England."

Dr. Kruss, of Hamburg: "Methods for Measuring the Light of Incandescent Burners in Germany."

Herr van Rossum du Chattel, of Amsterdam: "Methods for Measuring the Light of Incandescent Burners in Holland."

M. Lauriol, of Paris: "Photometry of Different Colored Lights."

M. E. Sainte-Claire Deville, of Paris:

First Memorandum—"The Illuminating Power of Coal Gas in Different Countries."

Second Memorandum—"The Illuminating Power in Incandescent Burners of Coal Gas Compared with that of Water Gas and of Mixtures of the Two."

Third Memorandum—"The Illuminating Power in Ordinary and Incandescent Burners of Coal Gas, Water Gas and Mixtures of these Two Gases, both With and Without Enrichment by Benzol."

Fourth Memorandum—"On the Proportion of Air for Combustion in Vivid Incandescence."

Charles Carpenter, of London: "Standard Test Burner for London Gas."

"Molten Platinum as a Unit of Light."

"Unification of Screw-Threads."

Comparisons of Light Standards:

Dr. Emil Liebenthal, of Berlin: "Investigations by the Physical Imperial Institute at Charlottenburg."

C. C. Patterson, of England: "Report made by the National Physical Laboratory to the Institution of Gas Engineers."

M. Perot and M. Janet, of Paris: "Report on the Researches Carried Out at the Testing Laboratory of the National Academy of Arts and Trades and at the Central Electricity Laboratory of Paris."

M. Laporte, of Paris: "Supplementary Investigation of the Relation Between Standard Flame Lamps—Carcel, Hef-Vernon Harcourt."

M. Laporte, of Paris: "Examination of Results Obtained for Ratios Between Three Standards—Carcel, Hefner and Vernon Harcourt."

Four resolutions were passed by the committee at this meeting, the first one expressing the wish that research should be continued in the interest of photometry on the fusing point of platinum; the second one again thanked M. Deville for his important communication and requested further research in the different countries on the relation between the maximum illuminating power and calorific power of the gas; the third the adoption of a suggestion of Prof. Drehschmidt of symbols for illuminating power, as follows:

I^h = Horizontal illuminating power.

$I\alpha^s$ = Illuminating power at an angle α to the horizontal above the horizontal.

Ia_i = Illuminating power at an angle a to the horizontal below the horizontal.

I_o = Mean spherical illuminating power.

$I_{\triangle}$ = Mean upper hemispherical illuminating power.

$I_{\triangledown}$ = Mean lower hemispherical illuminating power.

Maximum illuminating power in the upper (s) or

$I_m as$ = (lower (i) hemisphere, that maximum occurring

$I_m a^i$ = (at the angle a.

and fourth, again directing attention to utility of determining of illuminating powers of ordinary self-luminous flame burners and incandescent burners, both upturned and inverted, and to the establishment for the latter of the most satisfactory method of determining the M. H. S. and M. S. intensity, and these results be communicated to the committee.

(Third Session)

The official report of the third session of the International Photometric Committee, which met at Zurich from July 26th to 29th, 1911, inclusive, has not yet been made, but from the rather full extracts and comments which appear in the London Journal of Gas Lighting the following information is available:

That the committee has adopted the following relations between three light standards:—

Vernon Harcourt lamp = 1.035 Carcel = 11.10 Hefner.

The Photometric Committee takes note of the agreement concluded between the three National Laboratories of England, France and America as to the maintenance of a common illuminating unit, but they consider that it would be better not to give the name "International" to a unit which has not yet been accepted by certain important countries.

The questions of internal administration discussed are of peculiar importance to this Institute which has the appointing of American delegates.

It seems that the committee has been hampered in its work by (1) an insufficient number of members, (2) by lack of early or definite appointment of representatives from the different technical societies and (3) by the absence of any scheme for meeting the financial needs of the committee.

A fourth question for action was on the admission of representatives from the electrical interests, application for which had been made by the Association of German electricians.

As a result of the action taken America will now be entitled to three (3) delegates, having together one vote, and it is recommended that the appointments or reappointments be made as early after each committee session as possible, in order that committee organization and the delegating of research work may be effected.

The question of finance was carried over to the next session, which practically means that the next delegates attending should have received instructions from their appointing societies in this matter before the session.

The following resolutions were carried:

"The International Photometric Committee are of the opinion that, for questions common to both gas and electrical industries, the electricians be invited to participate in the meetings."

The Bureau of the International Photometric Committee to invite the National Electro-Technical Committee of the International Commission of Electricians to delegate two electricians for each country having six delegates and one for each country having three delegates to take part in the discussion on all questions of common interest.

It was further decided that in all matters before the committee where its imprimatur was desired, four-fifths of the votes expressed were necessary to carry it.

The commitee expressed its opinion as favorable to the calorific rather than the photometric test of the quality of gas. (See discussion in body of paper.)

Other subjects presented at the Third Session were:

Dr. Eitner, of Karlsruhe: "Methods of Photometry in use in Germany."

Messrs. Butterfield, Haldane and Trotter: "Corrections for the Effect of Atmospheric Conditions on Photometric Flame Standards."

"Photometric Dimensions and Units," a subject presented for consideration by the Illuminating Engineering Society.

Dr. Hugo Strache, of Vienna: "Flame Temperature and Incandescent Lighting Power."

M. Thovert, France: "A Technical Spectral Photometer."

The foregoing brief summary is sufficient to show the character, both of contributions and authors and, I think, to warrant the motion which has been presented in the body of the paper.

APPENDIX II.

As concerning the substitution of the calorific for the photometric test a letter containing the folowing questions and requesting a brief statement in reply to them was sent to the Secretaries of the Gas Associations in England, France, Germany, Holland and Italy:—

(1) When the change began?

(2) Whether any cases exist in which the same gas is legally subject to both tests?

(3) If the two methods of test are legalized, in what class of cities is the calorific test prescribed and in what class is the photometric test prescribed?

(4) In general, who have requested the change to calorific test?

(a) The consumers.

(b) The legislative bodies in response to scientific counsel, or

(c) The Gas Companies?

(5) What is the argument usually advanced for the change?

(6) What is considered a fair calorific requirement for manufactured illuminating gas and is this net or gross?

Replies were received from Germany, England and Italy as follows:

(From Germany)

"In the absence of General Secretary, Dr. K. Bunte, I have taken cognizance of the contents of your worthy letter of July 12th, and am sending for your information concerning the matter under consideration in Germany, a reprint of a report which I formerly made in Frankfort. You will see by this that in Germany where the majority of gas installations are owned by cities, especially in the larger cities, such as Berlin, Munich, Cologne, Breslau, Frankfort, Dusseldorf, Hamburg, Nuremburg, etc., almost without exception the calorimetric examination is made; and only rarely, unless there is a special contract, is the photometric test used.

Therefore, here in Germany we may safely state that the calorimetric test is universally applied where any inspection is provided for, unless it be that prior contracts require the photometric test.

The other contents of your letter will be noted later.

Respectfully,

H. Bunte.

(The report mentioned by Dr. Bunte appeared in the Journal für Gasbelluchtung Sept. 18, 1909, and an English translation appeared shortly afterward in the English Journal of Gas Lighting.)

(From England)

"In reference to your inquiries of the 13 th inst., addressed to our Mr. Dunn, the Secretary of the Institution of Gas Engineers, I beg to reply as under, viz:—

(1) The change cannot be said to have generally commenced in this country as yet.

(2) Yes! In the cases of the Gas Light and Coke Co., The South Metropolitan Gas Co., and the Commercial Gas Co., all of London; under the provisions of the London Gas Act, 1905, and the Gas Light and Coke Co.'s Act, 1909.

(3) The two methods are only legalized in London, as answer to Question 2; all others have a photometric test only prescribed.

In the case of London, the Gas Light & Coke Co., is the only company working under penal clauses with respect to calorific tests. In the cases of the other two companies, although calorific tests are equally compulsory with photometric test, calorific deficiency is ***not penalized,*** but photometric deficiency is liable to forfeiture specified in the Act.

(4) (*a*) No.

(*b*) Yes.

(*c*) No, as the gas companies of this country are quite content to work under the photometric test, with a standard (generally) of about 14 candle-power, at 5 cu. ft. per hour, as tested with the No. 2 Metropolitan Burner, which is rapidly displacing other standards.

(5) As there is as yet no great desire for the change, no leading line of argument for it has been adopted, but the main argument used for reduction in illuminating power standard is economy in production, accompanied by very slight calorific value, resulting in a cheaper and more efficient service to the consumer; the illuminating power of the gas "per se" being now of little consequence.

(6) The concensus of opinion would appear to be forming round about 125 calories net per cu. ft. In the Gas Light & Coke Co.'s Act, 1909, 125 calories net is adopted as the standard, but they do not incur liability for penalties unless it should fall below 112½ calories, net. The following is the scale of penalties imposed for deficiencies proved below 112½ calories net, viz:—

Deficiency not exceeding three calories net, maximum penalty five pounds.

Deficiency exceeding three calories, not amounting to six calories, net, maximum penalty ten pounds.

For each complete six calories further deficiency, penalty not less than twenty-five pounds, nor more than one hundred pounds.

Further not more than any one authority can recover forfeiture for any one attempt.

As showing the present transitory state of calorific standard,

it is further provided in the Gas Light & Coke Act, 1909, that the calorific standard may be modified, as may also the margins of deficiency and penalty, at the end of the first three, or any three successive years, should it be found desirable by either the local or municipal authorities, or the gas company.

Trusting the foregoing may meet your requirements and with kindest regards, I am,

Yours faithfully,

R. G. SHADBOLT,

President, Institution Gas Engineers.

(From Italy)

In conformity with the promise contained in my letter to you of August 24, 1911, beg to advise that I have communicated through our Association with all the leading cities of Italy (on the subject of the change from the Photometric to the Calorific test). As a result of these inquiries, I find that with the exception of Milan (600,000 inhabitants) and Modena (60,000 inhabitants), none of these leading cities have undertaken the Calorific test, but all of them still make use of the Photometric test only based on the Paris method, which is 105 liters per Carcel hour.

In Milan the Calorific test was imposed by the municipality in December 1901 in addition to the Photometric test and the prescribed quality is 5,100 (net) calories per cubic meter, with an allowable variation of 300.

In Modena the Calorific power test was imposed in 1896, specifying 3,350 calories per cubic meter (this by contract), and this in addition to the illuminating power requirement of 105 liters per Carcel hour.

I can give you no further authoritative information other than that in the several cities where the manufacture of gas is under municipal control, there is prescribed neither illuminating power nor calorific power.

Hoping to receive a copy of your paper, as well as a report of the Proceedings at the St. Louis Convention, I am, with best regards,

Sig. L. G. MAGGIONI.

The President: I regret I cannot ask for discussion on Mr. Bond's exceedingly scholarly paper. You have thanked him by your applause. The chair did not write the program. He is only doing his level best to carry it out. I understand that the report of the Committee on Thermal Value is a very short one. The report of the Calorimetry Committee was read yesterday—I want to open it for discussion at this meeting if possible, but I will call now for the report of the Committee on Thermal Value; that is all that remains of our program.

Report of the Committee on Thermal Value and Candle-power.

The report of this committee was made by its chairman, Dr. Alexander C. Humphreys, as follows:

October 17, 1911.

Report of Committee on Thermal Value and Candle-Power.

Your committee is not prepared at this time to make any definite recommendation in view of the experimental work now under way in America and foreign countries. Further time should be allowed for the investigation of the important questions involved in the testing of thermal values and candle-power of gases of varying composition. Your committee, however, wishes to endorse the several recommendations contained in Mr. Bond's paper just presented, as follows:

First. That this Institute promptly appoint three delegates to the International Photometric Commission, these delegates to be prepared to undertake individual investigations to be reported at the next congress of this commission in 1913; the officers of this Institute to notify the President of the commission of the appointment of the Institute's delegates, so that they may be assigned to such investigations as may be considered advisable by the President of the commission. The Institute's delegates to report progress to this Institute at its next convention.

Second. That the Secretary of the Institute be instructed to prepare a report of the proceedings of the three sessions of the International Photometric Commissions thus far held, this report to be incorporated in the proceedings of this Institute, preferably in the next volume.

Third. That the Technical Committee of this Institute be instructed to confer with the National Bureau of Standards as to the adoption of a standard test burner or burners to be employed in determining the illuminating quality of gases.

Fourth. In accordance with the communication from the Director of the Bureau of Standards to the Secretary of this Institute, your committee strongly recommends that the members of this Institute submit their pentane lamps to the Bureau of Standards for certification.

Your committee notes with pleasure that Mr. Bond is willing to submit a paper at the Institute's next convention on the photometry of incandescent gas lamps.

Respectfully submitted,

J. M. MOREHEAD,
R. M. SEARLE,
W. H. GARTLEY,
J. B. KLUMPP,
ALEX. C. HUMPHREYS,
Chairman.

THE PRESIDENT: Gentlemen, you have heard the report. What is your pleasure.

A motion was made and seconded that the report be accepted.

THE PRESIDENT: Gentlemen, a motion has been regularly made and seconded that the report be accepted and that the recommendations be concurred in. Is there any discussion?

The question was called for and on being put to a vote was carried without a dissenting voice.

MR. WARREN S. BLAUVELT: Mr. President, I wish to make a motion to the effect that the American Gas Institute appoint

a committee to establish standard methods for carbonization tests of coal.

THE PRESIDENT: Any second?

Several members seconded the motion.

THE PRESIDENT: It has been moved and seconded that the American Gas Institute appoint a committee to establish standard methods for the testing of the carbonization of coal. Those in favor of that motion will signify—

MR. A. E. FORSTALL: By whom is it to be appointed?

THE PRESIDENT: By the incoming President. The incoming President appoints all committees. All those in favor of the motion will signify the same by saying aye, contrary no.

The motion was carried without a dissenting voice.

MR. DOHERTY: I understand now that the report of the photometry committee is to come up. I want to move the postponement of that report until we have a larger attendance. I have several matters in relation to that report that I should like to bring up that I believe are of great importance to the Institute.

THE PRESIDENT: I am compelled to adjourn this meeting inside of the next three minutes. I cannot possibly bring it up. We will hear from Dr. Humphreys if the matter is short.

DR. HUMPHREYS: I should like to bring in a resolution in connection with the matter that has been brought to our attention by Mr. Searle. As I understood it, Mr. Searle did not intend any reflection whatever upon the President of this Institute. He intended a reflection upon all the past Presidents and all the members past and present.

MR. SEARLE: Quite right.

DR. HUMPHREYS: It seems to me that we do conduct our meetings inefficiently. I therefore want to offer the following resolution:

Resolved, That the officers of the Institute be requested to consider the several means that might be adopted to increase the efficiency of our meetings; and especially to consider the advisability of requiring papers to be filed with the secretary a sufficient time in advance of the meeting to permit the printing of papers and distribution to the members of the Institute residing in the United States at least two weeks in advance of meeting. The papers then to be read by title, supplemented by ten minutes' time to be allotted to the author to enable him to emphasize the essential points of his paper, preferably by a written abstract. Papers not filed with secretary within the time given not to be accepted.

THE PRESIDENT: Gentlemen, you have heard the resolution. Is there a second?

The resolution was seconded.

THE PRESIDENT: All those in favor of the resolution will signify the same by saying aye. (Ayes.) Contrary, no. (No response.)

The motion is carried. I declare this meeting adjourned until two o'clock, when we will meet here to listen to Professor Bone's lecture.

(Adjourned at 12.40 P. M.)

Thursday, October 19, 1911.

2 P. M.

The convention assembled at this time to listen to the lecture by Professor William A. Bone, D. Sc., F. R. S., Fuel and Metallurgical Departments, The University, Leeds, England, which was listened to with very great interest.

The lecture was followed by a series of practical demonstrations, which were of very great interest.

The following is the lecture:

SURFACE COMBUSTION.

Mr. President and Gentlemen:

I am deeply sensible of the honor you have conferred upon me in inviting me to cross the Atlantic for the purpose of laying before you some of the results of the investigation on the industrial applications of "Surface Combustion." My pleasure in accepting your invitation was all the greater because I believe that this Continent, with its courageous industrial enterprise and its vast resources in gaseous fuels, will afford a splendid field for the practical development of our new methods.

The problem of the influence of hot surfaces upon gaseous combustion is one which, from a purely scientific standpoint, has engaged my attention for many years past, and as my recent work has been the direct outcome of earlier scientific investigations, it will be appropriate for me by way of introduction to explain briefly the present position of science with respect to this important subject.

You will readily understand that a matter which is of great scientific interest as well as of practical utility can hardly be dealt with within the limits of a single lecture, especially when a considerable part of the time must be devoted to experimental demonstration. I must necessarily compress my remarks into the smallest possible compass consistent with clearness, omitting many points of secondary interest which otherwise it would have been profitable for me to discuss. I must make many statements both of fact and of opinion without advancing any demonstration or proof of them; I can only ask you to accept such statements as coming from one who, having devoted many years to the advancement of the science of combustion, would not willingly mislead you.

It would perhaps help you to an understanding of what is implied by the term *"surface combustion,"* if I first of all explain certain facts which differentiate it from the more familiar and perhaps better understood processes of combustion

as they occur in ordinary flames. In the first place, I would have you understand that all hot surfaces have an accelerating influence upon chemical changes in gaseous system; a recognition of this fact is of fundamental importance. It may be laid down as a well established principle that if at any temperature a gaseous system A, tends to pass over into another system B, contact with a solid at the same temperature will accelerate the process.

To take a very simple example, if a mixture of hydrogen and oxygen in their combining proportions (electrolytic gas) be maintained in an enclosure with smooth glass walls at a temperature of (say) 450° C., there would certainly be a tendency to form steam, but the rate of change would be negligibly small. If, however, there be brought into the system some porous solid material at the same temperature, so that a large surface is exposed to the gases, the rate of change would at once be rapidly accelerated in the layer of gas immediately in contact with the hot surface. Steam, the product, would diffuse outwards from the surface, and the supplies of hydrogen and oxygen at the surface would be renewed by diffusion inwards. Thus combustion would proceed heterogeneously at the surface until the transformation of the original electrolytic gas into steam was complete. In the circumstances just cited, the rate of combustion, although now quite measurable, would probably be insufficient to cause any self-heating of the enclosure. The temperature would remain at 450° C., which is well below either the ignition temperature of the combustible mixture or the point at which a solid would attain even incipient incandescence.

It is therefore necessary to distinguish between two possible conditions under which gaseous combustion may occur, namely (1) *Homogeneously*—that is to say, equally throughout the system as a whole, at temperatures *below* the ignition points *slowly and without flame,* and at temperatures *above* the ignition point *rapidly and with flame,*—and (2) *heterogeneously,* or only in layers immediately in contact with

an incandescent surface ("surface combustion"). It is also necessary to remember that, *ceteris paribus,* the heterogeneous surface combustion is a faster process than the normal homogeneous combustion of ordinary flames.

It has long been recognized as a scientific anomaly that metals of the platinum group have power of inducing gaseous combustion, more particularly that of hydrogen, but it has hitherto been generally considered that in industrial heating operations contact of all flame with surfaces should be avoided. Indeed, it was a favorite dictum of Frederick Siemens, who was the first to impress upon technologists the importance of radiation in furnace operations, that hot surfaces by promoting dissociation must necessarily hinder combustion. And in view of the great influence which Siemens exercised on contemporary thought, it is perhaps hardly to be wondered that technologists have hitherto never realized the possibilities of surface combustion in the field of industrial heating operations. I am convinced, however, that Siemens was wrong in his judgment concerning this matter.

It may be profitable for us to consider for a moment how far it is possible to accelerate the process of combustion in ordinary flames. We are apt to think of ordinary flame combustion as an instantaneous process, whereas when considered in terms of what I may call "molecular time," it is certainly a very slow transaction. Thus, for example, when electrolytic gas is ignited by a spark near the closed end of a tube, the flame is initially propogated by conduction with a uniform slow velocity of 20 meters per second, and during this preliminary period of *"inflammation,"* as it is sometimes termed. the total duration of chemical change in each successive layer of gas is of something like the order of one-fiftieth part of a second. But this is at least one hundred million times as long as the average interval between successive molecular collisions in electrolytic gas at the ordinary temperature. The conditions pervailing during the initial period of *"inflammation"* in a gaseous explosion correspond to those in ordinary flames, and it is at once apparent how very slow is the actual

chemical change when viewed from the standpoint of molecular time.

After the flame has traveled a short distance along the tube it is rapidly accelerated, under the influence of compression waves reflected from the closed end of the tube, until a new condition known as "detonation" is set up. In "detonation" the flame is propagated through the mixture by adiabatic compression at an enormously great and constant velocity, amounting in the case of electrolytic gas at atmospheric pressure to no less than 2,820 meters, or about 1¾ miles, per second. The combustion now proceeds under conditions of maximum intensity, both as regards the actual duration of chemical change and the temperatures produced in each layer of the burning gases. Some years ago, in conjunction with Dr. Bevan Lean, I found that the duration of chemical action in each successive layer of electrolytic gas in which *"detonation"* has been determined, does not exceed one five thousandth or possibly one ten thousandth part of a second, and Mr. D. L. Chapman of Oxford has calculated that the temperature attained is 4,265° C. Therefore, it would appear that although in "detonation" the duration of chemical change in each successive layer of electrolytic gas is probably about a hundred times shorter than in the preliminary period of "inflammation," it is still at least a million times as long as the average interval between successive collisions in the mixture exploded.

In order to give you visual evidence of the validity of this conclusion, I will throw on the screen a photograph taken by Professor Harold B. Dixon, of Manchester, of the progress of an explosion in electrolytic gas from its origin at a point a few inches from the closed end of a horizontal glass tube up to the attainment of its maximum force and intensity in detonation. (Fig. 1.) The flame was photographed on a highly sensitive film moving vertically at a velocity of about 50 meters per second, and the graph thus traced on the film was, therefore, compounded of the horizontal velocity of the flame along the tube and the vertical velocity of the film. The

black line on the photograph is due to a reference mark made by gumming a strip of black paper on the tube at a distance of one meter from its closed end. You will observe that the flame was initially propagated through the explosive mixture with a comparatively slow uniform velocity. Its luminosity during this initial period of "*inflammation*" (which corresponds to the conditions of ordinary flames) was comparatively feeble, and, from the slope of the graph, it is evident that its velocity was much slower than that of the vertical mo-

Fig. 1.

tion of the film. After traversing about 0.5 meter along the tube, its velocity was accelerated, and simultaneously the intensity of the combustion increased, as is indicated in the photograph by a brightening of the flame. The acceleration of the flame continued until, at a point just beyond the reference mark, "*detonation*" was set up. At this juncture the flame suddenly increased in brilliance and dashed forward through the mixture at a velocity many times greater

(as a matter of fact more than 50 times) than the vertical velocity of the film; at the same instant a strongly luminous wave of compression (called the *"rctonation wave"*) was sent backwards through the still burning gases. The luminous track of this retonation wave is to be ascribed to its accelerating influence upon the residual combustion in a mixture which had already been "inflamed," and it is evident from the photograph that this after-burning continued even after the "retonation wave" had been reflected back again from the closed end of the tube. Whilst this photograph has no *direct* bearing upon the question of surface combustion, it nevertheless proves beyond all question that the conditions prevailing in ordinary flames are such as admit of a great acceleration of the combustion, and it will, I hope, help you to understand what I shall subsequently refer to as the intensifying action of an incandescent surface upon gaseous combustion.

The influence of hot surfaces upon combustion at low temperatures seems to have occupied the attention of several chemists (Dulong and Thénard and independently Döbereiner in France, Sir Humphrey Davy, William Henry, Thomas Graham, Faraday and de la Rive in England) during the first third of last century, but no one of these distinguished men succeeded in evolving a satisfactory theory of the phenomenon. nor, with the exception of the famous "Döbereiner Lamp." was there any practical outcome of their efforts. In 1836, after a long but abortive controversy between Faraday and de la Rive, interest in the subject dropped and was not revived again until recent years.

My attention was first drawn to the subject about ten years ago during the course of an investigation on the mechanism of hydrocarbon combustion at low temperatures, which I was then engaged upon in conjunction with R. V. Wheeler and others of my pupils at the Owens College, Manchester (now the Manchester University). The subject soon became so absorbingly attractive that we embarked upon what proved to be a long enquiry into the influence of a great

variety of hot surfaces upon the combination of hydrogen and oxygen at temperatures below the ignition point. The enquiry has also included other cases of heterogeneous slow combustion, and I am hoping that experiments which are now being carried out in my laboratory at Leeds University will enable us to materially advance the theoretical aspects of the subject.

It would, however, be premature for me to attempt any prediction of our final conclusions, because several points remain to be cleared up, but I may safely say that our experimental results justify the conclusion that the power of accelerating gaseous combustion is possessed by *all* surfaces at temperatures below the ignition point in varying degrees dependent upon their chemical characters and physical texture. Moreover, the "activity" of a given surface can be enhanced or diminished at will by previous special treatment in a truly marvellous manner, thus, for example, in the case of the combination either of hydrogen or of carbon monoxide with oxygen in contact with a non-oxidizable metal or non-reducible oxide, the "activity" of the surface may be greatly stimulated by previous contact with the combustible gas and, conversely, may be diminished by previous contact with oxygen. Again there is abundant evidence that the actual surface combustion is dependent upon a prior "absorption (or condensation) of the combustible gas and (possibly also) of the oxygen by the surface (although to what extent the oxygen is involved is not as yet perfectly clear). The "absorbed" (or condensed) gas becomes "activated" (probably "ionized" as the physicists would call it) by association with the surface. Finally, certain important differences have been established between ordinary homogeneous combustion and heterogeneous "surface combustion"; thus, for example, whereas the presence of water vapor certainly accelerates, if it is not essential to, the homogeneous combustion of carbon monoxide, it greatly retards its heterogeneous combustion in contact with a surface such as fire-clay; or again, whereas methane has a much greater affinity for oxygen than either

hydrogen or carbon monoxide in ordinary flames, a hot surface, by virtue of some "selective" action, will completely reverse the usual order of things, a remarkable circumstance than which no better proof could be afforded of the reality of surface combustion.

My next contention, and one which leads right up to the main theme of my discourse, is that if hot solids possess the power of accelerating gaseous combustion at temperatures in the neighborhood of the ignition point, the same power must also be manifested at higher temperatures, and especially so when the surface itself becomes incandescent. Indeed my belief is that not only does the accelerating influence of the surface upon combustion rapidly increase with the temperature, but also that the difference between the powers of various surfaces (which at low temperatures are often considerable) diminish with ascending temperatures until at bright incandescence they practically disappear. If, therefore, an explosive gaseous mixture is either injected on to or forced through the interstices of a porous refractory incandescent solid under certain conditions, which will be hereafter explained, a greatly accelerated combustion takes place within the interstices or pores; or, in other words, within the boundary layers between the gaseous and solid phases where ever these may be in contact—and the heat developed by this intensified combustion maintains the surface in a state of incandescence *without any development of flame.* Such conditions realize my conception of *"flameless incandescent surface combustion"* as a means of greatly increasing the general efficiency of industrial heating operations where ever it can be conveniently applied.

There are two further points which I particularly wish to make clear to you. In dealing with gaseous interactions at high temperatures it is necessary to think in terms of what I may call "molecular" dimensions. Our ordinary units of time, space and mass are altogether too gross and must be discarded if we would wish to form a true mental picture

of the mechanism of combustion; when, therefore, I speak of combustion as occurring *"within the interstices or pores"* of an incandescent solid, it must be understood that I mean "porosity" in a molecular sense. A solid may appear to the eye, to be dense, and yet be highly permeable to the molecules of a gas; from this point of view it is only vitreous surfaces such as glass which are (relatively speaking) non-porous to gases, and even glass when it becomes devitrified is sufficiently porous to induce a slow surface combustion.

In the second place, I want to emphasize the fact that the incandescent solid plays a specific role in this surface combustion; it is no mere idle "looker-on" at the surging crowd of reacting molecules which swarm around it. On the contrary, it so galvanizes and incites the dormant affinities between the combustible gas and oxygen, that the stately minuet of ordinary flame combustion gives place to the wild intoxication of the Venusberg. The manner in which the surface acts is still perhaps a matter of conjecture but the fact that it so acts can no longer be disputed. In a discussion which took place at the British Association in 1910, Sir J. J. Thomson insisted that combustion is concerned not only with atoms and molecules, but also with electrons—*i.e.*, bodies of much smaller dimensions and moving with very high velocities, and suggested that "in reference to the influence of hot surfaces in promoting combustion, to which Professor Bone had drawn attention, it was not improbable that the emission of charged particles from the surface was a factor of primary importance." Those of you who may have followed recent developments of the corpuscular views of electrical action will remember how it has been proved experimentally that incandescent surfaces emit enormous streams of electrons traveling with high velocities and the actions of these surfaces in promoting combustion may ultimately be found to depend on the fact that they bring about the formation of layers of electrified gas in which chemical changes proceed with extraordinarily high velocity.

Leaving now the theoretical aspects of the subject, I will with your kind permission proceed to describe and in some cases to illustrate by experiment also, some of the more important features of the two processes of "incandescent surface combustion" recently evolved at the works of Messrs. Wilsons and Mathiesons, Ltd., of Leeds, where our experimental station is located. The experiments which I hope to show you were originally designed for lectures which I had the honor of giving at the Royal Institution of Great Britain about six months ago, and were subsequently repeated at the recent Glasgow meeting of the Institution of Gas Engineers. They are intended to convey to an audience of technical men a general idea of the wide field of practical utility which we believe lies before the new system; they are necessarily on a small scale and in most cases the rapid illustration of some striking effect is the main consideration.

(a) GENERAL CHARACTER AND ADVANTAGES CLAIMED.

The distinguishing and essential feature of the new processes is that a homogeneous explosive mixture of gas and air, in the proper proportions for complete combustion (or with air in slight excess thereof), is caused to burn without flame in contact with a granular incandescent solid, whereby a large proportion of the potential energy of the gas is immediately converted into radiant form. The advantages claimed for the new system are,—(1) the combustion is greatly accelerated by the incandescent surface, and if so desired, may be concentrated just where the heat is required; (2) the combustion is perfect with a minimum excess of air, (3) the attainment of very high temperatures is possible without the aid of elaborate "regenerative" devices; and (4) owing to the large amount of radiant energy developed, transmission of heat from the seat of combustion to the object to be heated is very rapid. These advantages are (as I believe) so uniquely combined in the new system that the resultant heating effect is,

for many important purposes not only preëminently economical but also easy of control.

(b) DIAPHRAGM HEATING AND ITS APPLICATIONS.

In the first process the homogeneous mixture of gas and air is allowed to flow under slight pressure through a porous diaphragm of refractory material from a suitable feeding chamber (see fig. 2) and is caused to burn without flame at the surface of exit which is thereby maintained in a state of red-hot incandescence. The diaphragm is composed of granules of fire-brick bound together into a coherent block by suitable means; the porosity of the diaphragm is graded to suit the particular kind of gas for which it is to be used, but for undiluted coal gas, for your carburetted water gas, a diaphragm so porous that the gaseous mixture will readily flow through it at a pressure of one-eighth inch water gauge is employed. (*At this point such a diaphragm was exhibited.*) The diaphragm is mounted in a suitable casing, the space enclosed between the back of the casing and the diaphragm constituting a convenient feeding chamber for the gaseous mixture which is introduced at the back. Such a mixture may be obtained in either of two ways, namely, (1) by means of suitable connections through a Y piece with separate supplies of low pressure gas and air, (2 or 3 inches w. g. only is sufficient), or (2) by means of an "injector" arrangement connected with a supply of gas at 2 lbs. per square inch pressure; the gas in this case draws in its own air from the atmosphere in sufficient quantity for complete combustion, the proportions of gas and air being easily regulated by a simple device.

To start up a diaphragm, gas is first of all turned on and ignited as it issues at the surface; air is then gradually added until a fully aërated mixture is obtained. The original flame

[1] Whereas in England the public gas supply is almost invariably either undiluted coal gas or coal gas mixed with a small proportion of water gas, I am informed that in America, carburetted water gas mixed with a small proportion of coal gas is usually supplied. The same texture of diaphragm is suitable for either supply.

W. A. B.

soon becomes non-luminous and diminishes in size; a moment later, it retreats on to the surface of the diaphragm which at once assumes a bluish appearance; soon, however, the granules at the surface attain an incipient red heat, producing a curious mottled effect; finally, the whole of the surface layer of granules becomes red-hot, and an accelerated "surface combustion" comes into play. All signs of flame disappear, and there remains an intensely glowing surface—a veritable wall of fire but without flame—throwing out a genial radiant heat which can be steadily maintained for as long as required.

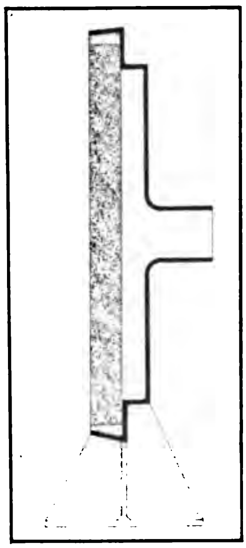


Fig. 2.

My assistant will now start up one of the diaphragms (area 1 sq. ft.) on the table, and you can judge for yourselves both of the quickness of the operation (it takes but a minute or two after starting up to attain full red heat) and of the beauty of the radiant effect produced. No one, I imagine, can see one of those diaphragms in operation and remain a disbeliever in the fact and potency of "Surface Combustion."

Whilst the diaphragm is in operation before you, I may point out some of the more striking features of the phenomenon which it presents. In the first place, the actual combustion is confined within a very thin layer (1/8 in. to 1/4 in. only) immediately below the surface, and no heat is developed in any other part of the apparatus; kindly observe that whilst the front of the diaphragm is intensely hot, the back of the apparatus is so cold that I can lay my hand on it. Secondly, the combustion of the gas, although confined within such narrow limits, is perfect, for when once the relative proportion of gas and air have been properly adjusted no trace of unburnt gas ever escapes from the surface. Thirdly, the temperature at the surface of the diaphragm can be instantly varied at will by altering the rate of feeding of the gaseous mixture; there is no lag in the temperature response, a circumstance of great importance in operations where a fine regulation of heat is required. The temperature of a diaphragm working on a coal gas and air mixture, at a given rate of feeding, depends on whether or not the intense radiation from its surface is impeded; with a freely radiating surface the temperature of a properly made diaphragm may be maintained at anything up to about 850° C. (say 1,550° Fahr.) according to the rate of supply of the combustible mixture. Fourthly, a plane diaphragm such as this may be used in any position, *i.e.*, at any desired angle between the horizontal and vertical planes. Fifthly, the diaphragm method is amenable to a variety of combustible gases. Coal or coke oven gas (either undiluted or admixed with water gas), natural gas, petrol-air gas, carburetted water gas are all well suited in cases where unimpeded radiation is required[1]. Also, we have constructed and successfully operated plane diaphragms of all sizes up to 4 square feet in area (2 ft. by 2 ft.) and are able to vouch from experience that their durability and radiant power are unimpaired even after long continued use.

[1] Subsequent to the delivery of the lecture experiments in England have proved that a useful radiant effect may also be obtained with "Mond Gas." W. A. B.

INCANDESCENCE NOT DEPENDENT ON EXTERNAL ATMOSPHERE.

A further important point to which I wish to direct your attention with regard to diaphragm heating is the fact that the incandescence of the surface in no way depends upon the external atmosphere.

When once the diaphragm has become incandescent, and the proportions of air and gas supplied in the mixing chamber at the back have been properly adjusted, the surface will maintain its incandescence unimpaired even in an atmosphere of carbon dioxide.

In order to demonstrate to you this point, there is here a chamber with a glass front which has been filled with carbon dioxide; this lighted taper is, you observe, at once extinguished when plunged into the chamber. My assistant will now plunge into the chamber a small diaphragm which is in a state of brilliant incandescence. (The diaphragm was plunged into the chamber.) You will observe that, although the surface is now surrounded by an atmosphere of carbon dioxide, its incondescence is unaffected.

APPLICATIONS OF DIAPHRAGM HEATING.

I need hardly point out to you the many obvious purposes to which "Diaphragm heating" may be applied. Grilling, roasting, toasting, are at once suggested; others will doubtless occur to you—such efficient means of attaining radiant heat can hardly fail to find new industrial uses. It will suffice if I demonstrate to you one which has perhaps the charm of novelty, namely, the evaporation and concentration of liquids by means of radiant energy emitted from a diaphragm fixed in a horizontal plane above the surface of the liquid. By means of this diaphragm mounted so that its incandescent surface is directed downwards, we will now evaporate a solution of sodium silicate (water glass), an operation it would be almost impossible to carry out satisfactorily by the ordinary means of heating the vessel by flame from below. By the new method however, only the topmost layers of the liquid are heated; the radiant energy of the diaphragm is instantly

transmitted to the surface of the liquid where it is absorbed and utilized for the evaporation. The sodium silicate separates out as a skin on the surface of the liquid, it is then dried by the radiant heat, and at intervals the crust of dry sodium silicate may be skimmed off. In this way, we are not only able to evaporate the solution with a great economy of heat, but we are also able to complete the evaporation of highly concentrated solutions much more easily than by means of heat applied from below.

INCANDESCENT SURFACE COMBUSTION IN A BED OF REFRACTORY GRANULAR MATERIAL.

The second process is applicable to all kinds of gaseous or vaporized fuels and can be adapted to a great variety of both small and large scale industrial heating operations. It consists essentially in injecting through a suitable orifice, at a speed greater than the velocity of back firing, an explosive mixture of gas (or vapor) and air in their combining proportions into a bed of incandescent granular refractory material which is disposed around or in proximity to the body to be heated.

I can perhaps best describe the process by the aid of two diagrams showing its applications to the heating of crucible and muffle furnaces. The first slide on the screen, (fig. 3) shows the process as applied to a crucible furnace. The crucible is surrounded by a bed of highly refractory granular material. The mixture of gas and air is injected at a high velocity through a narrow orifice in the base of the furnace, and as it impinges upon the incandescent bed combustion is instantaneously completed without flame.

The seat of this active surface combustion is in the lowest part of the bed, the burnt gases, rising through the upper layers, rapidly impart their heat to the bed maintaining it in a high degree of incandescence. The next slide (fig. 4) shows a similar arrangement for the heating of a muffle furnace, an arrangement which needs no further explanation.

It is obvious that this process is adaptable to many other furnaces operations, as for example, to the heating of retorts,

annealing furnaces, and the like. Moreover, it is not essential that the bed of refractory material shall be disposed around the vessel or chamber to be heated; it may be equally well packed into tubes, or the like, traversing the substance or medium to be heated. This latter modification is, as we shall see later, important in relation to the melting of metals or alloys which are fusible at temperatures below about 600° C., and also in relation to steam raising in multitubular boilers. By this process much higher temperatures are attainable with

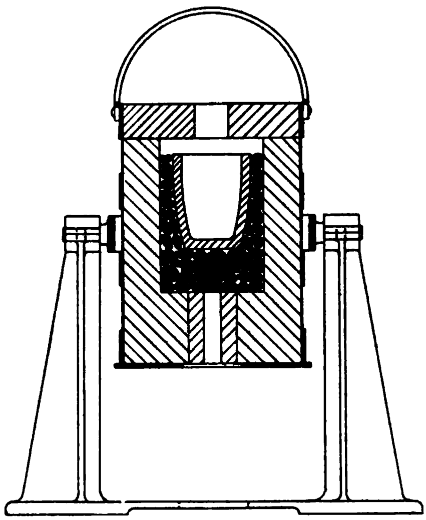


Fig. 3.

a given gas than by the ordinary methods of flame combustion without a regenerative system, and as a matter of fact, we have found that with any gas of high calorific intensity (such as coal gas, water gas, or natural gas) the upper practicable temperature limit is determined by the refractoriness of the material composing the chamber to be heated, (i.e., the muffle or crucible) rather than by the possibilities of the actual combustion itself. When I tell you that in a crucible fired by coal gas on this system we have melted "Seger-cone" No. 39, which according to the latest determination of the

Reichsanstalt in Berlin, melts at 1,880° C., and also that we can easily melt platinum, you will appreciate the possibilities of the method in regard to high temperatures with gas fired furnaces. Indeed, at one stage of the investigation, we had considerable difficulty in obtaining materials for the construction of muffles and crucibles which would stand the high temperatures obtainable with coal gas, but we have now succeeded in constructing muffles which will stand temperatures up to 1,400° or 1,500° C.

It will also be obvious that the bed of incandescent

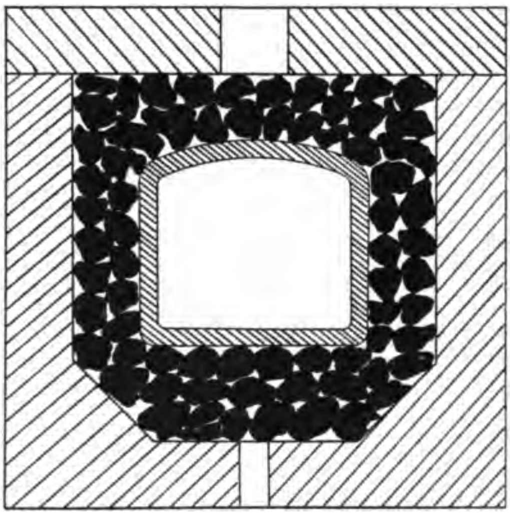


Fig. 4.

granular material must be composed of a substance which will not at the working temperature exercise a fluxing action upon the walls of the crucible or muffle, or walls of the furnace. For the very high temperatures obtainable with coal gas, water gas or natural gas, we employ a bed composed either of fragments of magnesia, which has been burned at a high temperature or of a neutral and highly refractory material specially prepared for us. In cases where the temperature required does not exceed 1,200° C. the bed of refractory

material may be composed of a good quality of fire-brick crushed and meshed to a suitable size.

To start up a furnace, gas is first of all turned on and lighted as it issues from the top of the furnace; the air supply is then gradually opened until the flame strikes back through the granular material and is arrested at the orifices in the base of the furnace through which the explosive mixture enters. The flame raises the granular material in the neighborhood of these orifices to a state of incandescence after which "surface combustion" quickly supercedes the flame. As soon as the lower regions of the bed have become thoroughly incandescent, the rate at which the mixture is being fed into the furnace may be materially increased, so that the whole of the lower region of the incandescent bed soon becomes the seat of a very intensive surface combustion.

As I have already stated, the method is applicable to all kinds of gaseous and vaporous fuels, but naturally the maximum temperature obtainable in any given case will depend upon the volume and heat capacity of the products for a given heat development in the bed. Thus, whilst with actual coal gas, water gas, or natural gas, it is possible to attain temperatures of up to at least 2,000° C., with a producer gas of low calorific intensity such as Mond gas, about 1,500° C. would probably be the maximum temperature obtainable without regeneration. With some degree of heat recuperation, which in such a case would be quite practicable, in all probability this limit could be considerably exceeded.

In order to give you some idea of the heating efficiency of this process I have drawn up in tabular form on the next slide (fig. 5) the results of a test on a muffle furnace in which a muffle 9½ in. long by 5¼ in. wide by 3¼ in. high (inside dimensions) was heated to temperatures between 815° and 1,425° C., with a fully aërated coal gas of 540 B. Th. U's. (net) per cubic foot.

The conditions under which the test was carried out made possible the accurate determination of the rate of gas con-

sumption requisite to maintain the muffle at any constant temperature between 815° and 1,425° C. The temperatures given in the first two columns are those recorded by a standard thermo-junction placed in the middle of the muffle. The temperature of the escaping products was also ascertained by means of a standard thermo-junction. I particularly want you to observe that the temperature of the products is in every case some 300° to 350° C., lower than

Fig. 5.

RESULTS OF TEST ON A MUFFLE FURNACE.

Dimensions of muffle, 9½″ × 5¼″ × 3¼″.

Temp. in middle of muffle Cent.	Fah.	Gas consumption to maintain temp. constant Cu. ft./Hr. at 15°C.	Temp. of products Cent.	Fah.
815°	1499°	21.0	540°	1004°
1004°	1840°	35.3	645°	1195°
1205°	2201°	58.0	870°	1598°
1424°	2596°	79.0	1085°	1985°

Mean net cal. val. of gas = 540 B. Th. U's per cu. ft. at 15°C.

that of the muffle, and that even with a muffle temperature of 1,424° C., there was no appearance of flame whatever at the top of the furnace. The gas consumptions recorded in the middle column are extremely economical in comparison with ordinary heating by flame contact. Thus for example, in a similar test with a muffle of the same size heated by flame contact in a furnace of modern design, the gas consumption to maintain the muffle at 1,055° C., (which was the maximum temperature obtainable) was 105 cubic feet per hour, whereas by interpolation from the above numbers the consumption in the "surface combustion" furnace at the same temperature would have been about 43 cubic feet per hour only.

SURFACE COMBUSTION AS APPLIED TO STEAM RAISING IN MULTITUBULAR BOILERS.

I now come to a very important application of our process to the raising of steam in multitubular boilers, and to the melting of metals and alloys. I will first of all take the sub-

ject of steam raising, and by the aid of lantern slides I will endeavor to explain to you the construction and performances of a new type of gas fired boiler in which the principle of surface combustion is utilized.

It is well-known that hitherto the gas firing of steam boilers has not been very successful from the point of view either of thermal efficiency or of rate of evaporation. In this country you have a variety of gases available for steam raising purposes for example (1) blast-furnace gas, (of which there is always a large surplus available from the blast-furnace plants), (2) the surplus gas which is obtained in the manufacture of coke in by-product ovens, (3) natural gas of which you have abundant supplies in many localities and (4) producer gas of various compositions, but more particularly that manufactured under "ammonia recovery" conditions. All these gases have been found amenable to the system I am about to describe.

It has been estimated by a prominent English blast-furnace engineer that the efficiency of the best type of water-tube boiler, fired by blast-furnace gas, does not exceed about 55 per cent. From careful observations which were made at my instigation on a battery of Lancashire boilers fired by blast-furnace gas, evaporating water previously softened to within 4 degrees of hardness, with an attachment of the most approved type of economizers, (so that the temperature of the burnt gases going to the chimney was reduced to the lowest possible point consistent with good draft), it was proved that the thermal efficiency does not, under the best of conditions, exceed 60 per cent.

With regard to similar boilers fired by coke-oven gas, I think one can safely say that the average thermal efficiency of steam-raising does not exceed 65 per cent., and in exceptional cases it may amount to perhaps 70 per cent.

It must therefore be confessed that the substitution of gas for raw coal in boiler firing has hitherto not been conducive to fuel economy and indeed in England boilers are rarely gas-fired except when there are supplies of "surplus" gases

which cannot well be utilized in any other way. But on applying the principle of surface combustion to the gas-firing on multitubular boilers, we have been able to obtain results corresponding to the transmission of nearly 95 per cent. of the energy represented by the *net* calorific value of the gas to the water in the boiler. I will now explain the construction and mode of operation of the new boiler.

The diagram on the screen (fig. 6) represents an ordinary multitubular boiler of cylindrical section. It is traversed hori-

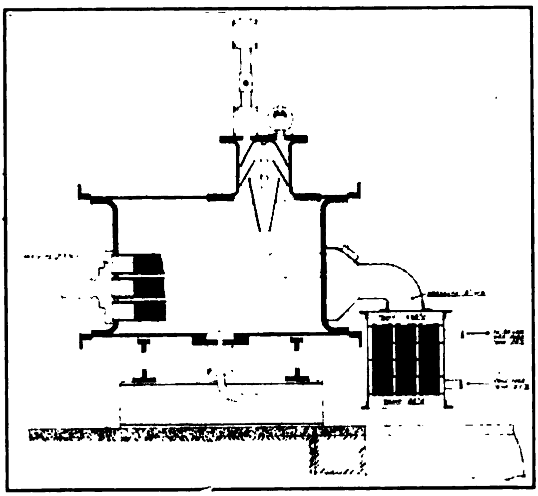


Fig. 6.

zontally by a series of steel tubes, each 3 feet only in length and 3 inches in internal diameter. These tubes are packed throughout their whole length with fragments of a suitable refractory material, meshed to a proper size. Into the front end of the tube, where the gaseous mixture is introduced, is fitted a fire-clay plug, through which is bored a circular hole of about ¾ inch diameter. This plug serves a double purpose of keeping the front end of the boiler cool, and of providing a suitable aperture through which the gaseous mix-

ture may be introduced at a speed very much higher than the speed of back-firing.

Attached to the front plate of the boiler is a mixing chamber of special design. (Not shown in detail on the diagram.) The mixture fed into the boiler-tubes from this chamber consists of the combustible gas with a proportion of air very slightly in excess of that required for complete combustion. The mixture is injected or drawn in (either by pressure or by suction), through the orifice in this fire-clay plug, on to the incandescent material in the tubes. The combustion of the mixture in contact with the incandescent material is completed before it has traversed a distance of about 6 inches from the point of entry to the tube. The result is that the core of the material at this part of the tube is maintained at a high temperature, although the *loci* of actual contact between the hot material and the walls of the tube are so rapidly cooled by the transmission of heat to the water in the boiler that they never attain a temperature even approaching red-heat.

The combustion having been completed, the remainder of the material acts as a baffle toward the burnt gases as they traverse the tubes at a high velocity, causing them to impinge repeatedly on the walls of the tubes. The usual rate at which the gaseous mixture is fed into the boiler corresponds to an hourly consumption of about 100 cubic feet of coal gas *plus* six times its volume of air for every tube of the boiler, or an equivalent volume, (*i.e.* equivalent as regards heating capacity) of any other gaseous mixture. Thus in the case of a ten tube boiler, on which our original experiments were made, the consumption of coal gas was about 1,000 cubic feet per hour plus about 5,500 or 6,000 cubic feet of air. This will convey an idea of the extremely rapid rate at which the mixture is caused to traverse the tubes.

UTILIZATION OF THE HEAT IN THE EXIT GASES.

After the burnt products have traversed the boiler-tubes, and at their point of exit therefrom, it is found that their

temperature is never more than about 70° C. above that of the water in the boiler, which, of course, depends upon the pressure at which the steam is being generated. This is a much lower temperature than that at which the products of combustion usually pass away from a multitubular boiler. But in order to increase still further the output of steam, the products are passed through a short tubular feed-water heater constructed on the same principle as the boiler.

THE TEN-TUBE EXPERIMENTAL BOILER.

I will now briefly describe, by the aid of photographs

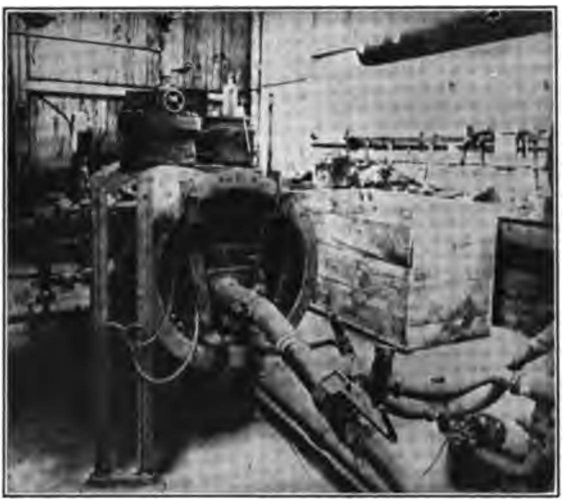


Fig. 7.

and slides, the construction and performance of the 10-tube boiler on which we have been experimenting for upwards of a year in Leeds. The connections to the front of the boiler (fig. 7) consist essentially of a tube for the supply of gas, and another for the supply of air. The gas and air are mixed before entering the feeding chamber attached to the front plate of the boiler; the gaseous mixture is burned in the tubes of the boiler; the products pass

outwards at the other end into a small chamber and from thence into the feed-water heater. The latter contains nine tubes, each 1 foot in length and 3 inches diameter, which are filled with granular material to effect the exchange of heat.

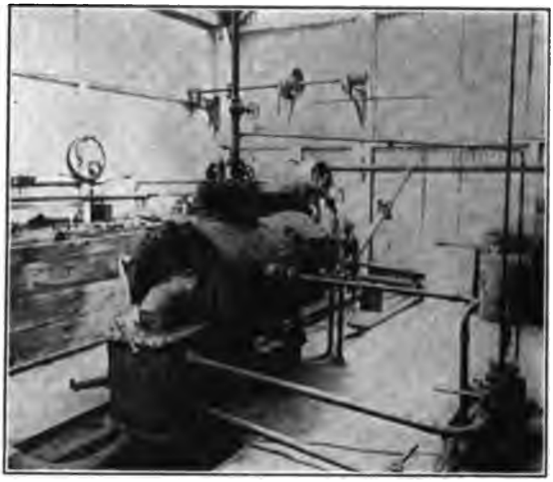


Fig. 8.

The second view of the boiler (fig. 8) shows the end at which the burnt gases make their exit.

RESULTS OBTAINED WITH THE BOILER.

As there is no coke oven gas or producer gas available at our experimental station we have been compelled to employ Leeds coal gas, which at a half a dollar per 1,000 cubic feet is a very costly boiler fuel. But there is no doubt that had we been able to use the surplus gas from by-products coke ovens (which has practically the same composition and calorific value as Leeds coal gas), we should have obtained the same results as with the Leeds gas. The mixture of gas and air was passed into the feed chamber of the boiler at a pressure of 17.3 inches water-gauge. This pressure is necessary in order to overcome the resistance of the packing of

the tubes to the passage of the gases through them. The pressure of the products entering the tubes of the feed-water heater was 2 inches water-gauge.

In carrying out the test, the water was evaporated at a pressure of 100 lbs. per square inch above that of the atmosphere; the temperature of the boiling water was therefore 168° C. (or 337° Fahr.). The temperature of the combustion products leaving the boiler tubes was 230° C. The average temperature of the products leaving the feed-water heater was 95° C. (or 203° Fahr.). The temperature of the water entering the feed-water heater was 5.5° C. (or 42° Fahr.), and it was heated to 58° C. (or 136.4° Fahr.) before entering the boiler, entirely at the expense of the burnt gases.

Let us now consider the heat-balance of the boiler during the test. The amount of coal gas fed into the boiler expressed as dry gas at 0° C. and 760 mm., was 996 cubic feet per hour. The net calorific value of the gas was 562 B. Th. U's. per cubic foot, so that the total heat supplied to the boiler, in terms of the net calorific value of the gas, was 559,800 B. Th. U's. per hour.

As to the amount of water evaporated, the following figures apply to the combination of the boiler with its feed-water heater, because the two really comprise one steam-raising system. The temperature of the feed-water was 5.5° C., and the steam was being raised at a temperature of 100 lbs. per square inch above that of the atmosphere. The actual amount of water evaporated was 450.3 lbs. per hour, which in terms of water evaporated from and at 100° C. would be 550 lbs. per hour. The actual heat therefrom transmitted to the water was 450.3 $\times$ 1,172=527,800 B. Th. U's. per hour. The ratio between the heat transmitted to the water and the net heat of combustion of the gas burnt in the boiler, therefore was 0.943.

It is one of the outstanding merits of the new system that we are able to burn the gas completely with a minimum excess of free oxygen, and during the test in question the average proportion of carbon dioxide in the combustion products

was as much as 10.6 per cent., whilst the oxygen was as low as 1.6 per cent. The most careful examination of the products failed to reveal the presence of the slightest trace of CO, H_2 or CH_4. Therefore the remainder of the gas was simply nitrogen. Even with as little as 0.5 per cent. of oxygen in the products, the combustion of the gas in the tubes is perfect, not a trace of combustible gas escaping.

THE 110-TUBE BOILER FOR COKE-OVEN GAS.

Recently erected at the Skinningrove Iron-works in Cleveland. (Yorkshire.)

That the gas firing of boilers according to the new system

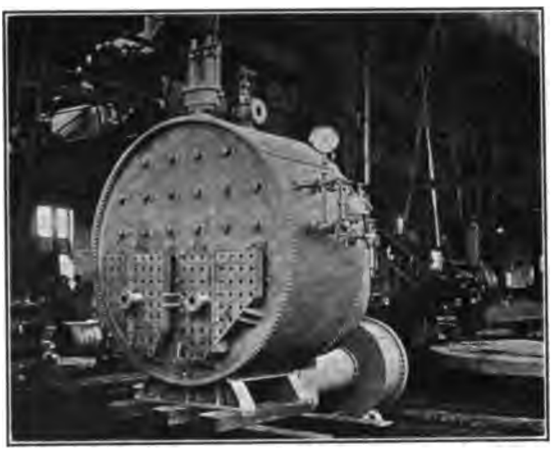


Fig. 9.

has now been advanced beyond the merely experimental stage is proved by the recent erection of a 110-tube boiler capable of evaporating not less than 5,500 lbs. of water per hour, to the order of the Skinningrove Iron Co., Ltd., (the Cleveland District, Yorkshire), to be fired by gas from a new installation of Otto-Hilgenstock By-product ovens adjacent to their blast furnaces. I have brought with me slides (figs. 9 and 10) made from photographs of the boiler with its feed water

heater as erected in the shops of Messrs. Richardson and Westgarth, Middlesbrough, the builders. The boiler itself is a cylindrical drum 10 ft. in diameter and only 4 feet from front to back; it is traversed by 110 tubes of 3 inches internal diameter which are packed with fragments of fire-brick. The boiler will be worked under the suction of a fan, capable of producing a "suction" of 20 inches water gauge. To the front of the boiler is attached a device whereby gas at 2 in. w. g. pressure from a suitable feeding chamber, together with a proper proportion of air from the outside atmosphere, is drawn (under the suction of the fan) through a short "mixing tube" into each of the 110 tubes of the boiler where it is burnt without flame in contact with the incandescent granular material. The products of combustion, having traversed the 4 ft. length of packed tube, will pass outwards into a semicircular chamber at the back of the boiler, and thence through a duct to the tubular feed water heater which is depicted in the second photograph. The fan, which is attached to this feed water heater, will suck out the cooled products and discharge them through a short duct into the atmosphere outside the boiler house.[1].

I have perhaps already said enough about the boiler and its working to convince you that it at least gives promise of combining structural simplicity, high thermal efficiency and concentration of power in a degree which is absolutely unique. From the constructional point of view nothing could be simpler or more compact than a cylindrical shell only 4 feet long by 10 feet in diameter, supported on a casting and requiring neither elaborate brick-work setting nor chimney. It has the further structural advantage over all other multitubular boilers in that the front plate can never be heated beyond the

[1] Subsequent to the delivery of the lecture, this boiler was successfully started up (Nov. 7th) for a month's continuous run—day and night—after which it was opened up (Dec. 8th) for an official inspection by a prominent British boiler insurance company. The boiler ran without a hitch throughout the whole trial on water at 5° hardness; there was absolutely no "priming," and the average temperature of the burnt gases on leaving the feed water heater was 75° centigrade. Before the month had elapsed the plant was taken over and paid for by the Skinningrove Iron Company. When opened up for the official inspection the boiler tubes were reported to be in splendid condition and free from scale. W. A. B.

temperature of the water, however much the firing may be forced, a circumstance which, coupled with the extremely short length of the tubes, implies an absence of strain and greatly reduces the risk of leaky joints. Another feature of the boiler, which makes for efficiency, is the steep "*evaporation gradient*" along the tubes. Under the normal working condition, the "*mean evaporation*" exceeds 20 lbs. per square foot of heating surface or about twice that of a locomotive boiler. Of the total evaporation no less than 70 per cent. occurs over the first part length of the tubes, 22 per cent. over

Fig. 10.

the next part and about 8 per cent. over the third part. Such a steep gradient causes a considerable natural circulation of the water in the boiler, a factor of great importance from the point of view of good working. In regard to thermal efficiency, I venture to claim that a boiler unit which, whilst evaporating 20 lbs. of water per square foot of heating surface, transmits upwards of 90 per cent. of the net heat of combustion of the gas to the water, and which if need be, can be forced to a 50 per cent. higher "duty" with only a slight drop in efficiency as a steam raiser from gaseous fuel is unsurpassed. Moreover, in the case of a large boiler of (say)

100 tubes, "elasticity" may be conferred by arranging the tubes in groups so that they may be either fired up or conversely shut off, group by group, successively, in correspondence with variations in the load.

THE MELTING OF METALS AND ALLOYS.

It will be readily understood that the principle embodied in the boiler is capable of great extension, thus for example:—(1) to the preliminary concentration of dilute solutions and the heating of liquids generally ;(2) to the heating of large volumes of air; and (3) to the melting of metals and alloys.

Unfortunately, time does not permit of my dealing with these further applications in every detail. I should like, however, to refer briefly to the results of our experiments upon the fusion of metals. Our attention was first drawn to this subject by one of the London Gas Companies, who represented to us that there would be a large field of usefulness for our process in the melting of type metal for newspaper purposes. The printing of a newspaper of large circulation necessitates a continuous supply of molten type metal and we are reliably informed that a leading London newspaper requires 20 tons of molten type metal continuously at hand during 16 out of the 24 hours. In the experiments which I now propose to describe to you, lead has been used instead of the more expensive type metal, but the method is applicable to all metals or alloys whose fusion points lie below about 600° C. The diagram (Fig. 11) on the screen represents an iron tank, efficiently lagged and filled to the top with molten lead at a temperature some 50 degrees or thereabouts above its melting point. In the molten bath is fixed an iron tube some 2 or 3 feet in length and of three inches internal diameter. This tube is packed (like one of the boiler tubes) with a suitable granular refractory material and there are suitable arrangements for the introduction of the explosive mixture of gas and air which is to be burned therein. When once the device has been started up it will work continuously for days together. Solid lead is continuously fed into the apparatus and the molten metal is allowed to run

over through the spout indicated in the diagram. For the sake of simplicity I have described and illustrated a small tank fitted with one combustion tube, but experiments have been carried out with tanks holding up to 8 tons or more of molten metal in which a series of combustion tubes are fixed. By the means of such an apparatus, lead (or other fusible metals or alloys) may be melted not only very rapidly but with extraordinary efficiency, and as an example of this, I will quote the results of a test carried out at our experimental station with

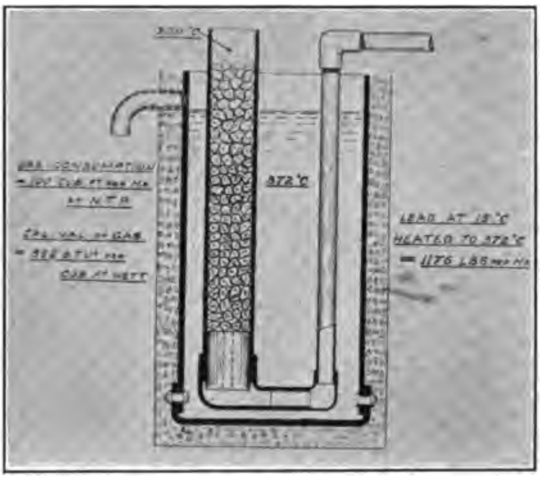


Fig. 11.

a single tube apparatus. These may be conveniently tabulated as follows:

The conditions of the test were so arranged that the mean temperature of the molten metal in the apparatus (as ascertained by a thermo-junction) was 372 ° C., throughout the test. Lead ingots each weighing about 30 pounds were added at intervals of 1½ minutes, the molten metal displaced was simultaneously run off into moulds. Great care was taken to keep the bath thoroughly molten and at a temperature within a few degrees of the mean value. Burning gas, of net calorific value

559 B. Th. U's. per cubic foot, at the rate of 100 cubic feet per hour, it was found possible to raise the temperature of 1,176 pounds of lead per hour from 15 degrees to 372° C., the temperature of the products of combustion leaving the tube keep-

Fig. 12.

LEAD MELTING TEST.

	Cent.	Fah.
Temp. of metal charged	15°	60°
Temp. of metal tapped	372°	682°
Temp. of gases leaving apparatus	500°	932°

Lead melted per hour = 1176 lbs.

Heat required per hour to raise metal from 15°C. to 372°C. = 1176 × 32.67 = 38.420 B.Th.U.

Gas burnt per hour = 100 cub. ft. at N.T.P.

Net. cal. val. of gas = 559 B.Th.U. per cu. ft. at N.T.P.

$$\text{Ratio} = \frac{38.420}{55.900} = 0.686.$$

ing constant at 500° C., or only 128 degrees above the temperature of the molten metal. From the latest determination by Spring of the specific heat of lead at temperatures up to and above its melting point, and adopting the usually accepted value for the latent heat of fusion of lead, I calculate that the heat required to raise the temperature of 1 pound of lead from 15° C to 372° C. (including melting) is 32.67 B. Th. U's. Therefore the heat transmitted to the lead per hour during the experiment was 1,176×32.67=38.420 B. Th. U's. whereas the *net* calorific value of the gas burnt per hour was 55,900 B. Th. U's. the ratio $\frac{38,420}{55,900} = 0.686$. Inasmuch, however, as the *net* heat of combustion of the gas is based on the assumption that the products of combustion (less steam) are cooled down to 15° C., whereas in the experiment the temperature of the molten metal was 372° C., it follows that the high ratio of 0.686 does not do full justice to the merits of the system. Under "ideal" conditions the temperature of the gases leaving the combustion tube could not have been reduced below 372° C., they were actually reduced to within 130 degrees of this "ideal" temper-

ature. Taking these circumstances into consideration, I calculate that the "efficiency" of the melting operations was practically 80% of that theoretically possible. The balance of 20 per cent. would be made up of (1) heat carried off in the waste gases which under ideal conditions might have been utilized, and, (2) radiation losses.

Having concluded the formal part of my lecture and before the further experimental demonstration is resumed, I wish to express my great obligation to the authorities both of the University of Leeds and of the Imperial College of Science and Technology, in London, for granting me leave of absence from my teaching duties and engagements in order that I might appear before you this afternoon. The University of Leeds has recently formed a very close association with the coal gas industry in Great Britain, and the endowment of the chair which I have the honor of occupying at Leeds University, in memory of the late Sir George Livesey, is the sign and seal of this alliance.

We, of the Leeds University, attach great importance to the organization and development of our departments of Applied Science, and I am authorized by my friend, Professor Smithells, our Pro-Vice Chancellor and Dean of the Faculty of Science, whose researches on the structure and chemistry of flames are familiar to all gas engineers, to convey to the American Gas Institute, cordial greetings from the University of Leeds.

EXPERIMENTAL DEMONSTRATION.

During the demonstration which followed the lecture the following experiments were shown:

(*a*) Diaphragm Heating.

(1) Two square diphragms (each 1 foot by 1 foot), mounted as described in the lecture (see Fig. 2) were lighted up. Gas alone was first turned on and ignited by a taper as it issued from the face of the diaphragm, giving rise to a large luminous

flame. Air was next gradually added; the flame diminished in size and after a momentary increase in brightness soon became non-luminous. A moment later, it retreated on to the surface of the diaphragm, causing it gradually to glow. As the glow of the surface increased the flame gradually disappeared until finally, when the whole of the surface had attained bright incandescence, it could no longer be detected. The diaphragms were now emitting an intense radiant heat the influence of which could be felt far into the auditorium. The lecturer pointed out that although the front of the diaphragm was in a state of bright incandescence, the back of the apparatus was so cold that he could lay his hand upon it; indeed it felt cold to the touch.

(2) A circular diaphragm, in a state of bright incandescence, was plunged into a chamber full of carbon dioxide and through which a current of carbon dioxide was uninterruptedly passed. The front of the chamber facing the audience was of glass. It was seen that the incandescence of the diaphragm was in no way diminished on being placed in the chamber, a circumstance due to the fact that sufficient air to completely burn the gas is introduced into the feeding chamber at the back of the diaphragm and also that the flameless combustion at the surface of the diaphragm is instantaneously completed.

(3) The application of the diaphragm principle to the concentration and evaporation of liquids was demonstrated by directing the radiant heat from a diaphragm downwards on to the surface of a solution of sodium silicate contained in a large porcelain basin. The lecturer pointed out how in this way the layers of liquid immediately below the surface only were heated, the main body remaining cold, except for a small amount of heat conveyed to it by conduction. No sooner had the experiment begun than a rapid evaporation in the surface layers of the liquid could be observed. This was succeeded by the formation of a skin of sodium silicate which was periodically removed by means of a glass rod; the salt separating out at the surface was speedily dried by the radiant heat and when re-

moved was in the form of a dry snow-like mass which could be easily powdered by slight pressure in the palm of the hand. The lecturer again reminded his audience that the rapidity and efficiency of this new method of evaporation depended on the fact that the required energy was transmitted from its source to the liquid instantaneously in a radiant form, instead of (as in existing methods) relying chiefly on the infinitely slower transmission by either conduction or convection.

(*b*) Steam Raising.

The lecturer explained that it had not been found practicable to carry across the Atlantic the small three-tube experimental boiler (capable of steaming at one hundred pounds per square inch pressure) exhibited at the Royal Institution of Great Britain on April 6th last. In substitution, he had brought over with him a single tube, three feet in length and three inches in internal diameter, suitably mounted on a trough of water which was open to the atmosphere. The tube was fitted with a fire-clay plug, and packed with suitable refractory granular material, exactly as in the case of the boiler tubes. He would now fire up the tube with a mixture of gas and air on the new principle explained in the lecture, and he would afterwards invite the audience to file past the trough in order that each person might judge for himself of the extraordinary efficiency and rapidity of the evaporation. A centigrade thermometer would be placed with its bulb in the end of the tube from which the burnt gases made their exit, and the lecturer predicted that the temperature would now rise beyond about 210°, when gas at the rate of one hundred to one hundred and twenty cubic feet per hour *plus* the air required for complete combustion was being burnt in the tube. (This was subsequently verified.) He would ask the members of the audience to notice how the greater part of the evaporation, actually seventy per cent. of the whole, took place over the first foot of the tube, a circumstance which produced a vigorous natural circulation in the boiler.

(*c*) The Firing of a Muffle Furnace.

A furnace carrying a muffle nine and one-quarter inches long by five and one-quarter inches wide by three and one-quarter inches high (inside measurements) was next fired up as described in the lecture. As the lecturer explained it would take about thirty minutes for the furnace to attain anything like its full working temperature, which in this case would be about 1,400° to 1,500° centigrade—a dazzling white heat. He would ask those of the audience who wished to stay until this was attained, to note three things, namely, (1) the uniform heating of the muffle chamber, (2) the flamelessness of the combustion and (3) the comparative coolness of the burnt gases issuing from the two holes at the top of the furnace. Indeed he would venture to predict that it would be found possible to hold a hand in these products within two or three inches of their issuing from the furnace. (These points were subsequently verified by a number of persons who remained to see the furnace at its full working temperature.)

(*d*) Experiment Showing the Melting of Platinum on a Crucible Fired According to the New Principle.

As a final experiment, the lecturer placed a roll of platinum foil in a small crucible of very refractory material, which was then placed in a suitable cylindrical furnace containing a bed of refractory granular material. The mixture of gas and air was then injected and caused to burn in the bed of granular material, speedily raising it to white heat. After about twenty minutes, the lecturer was able to announce the melting of the platinum. On removing and cooling down the crucible, the bead of platinum, somewhat larger than a full sized grain of wheat, was found at the bottom of the crucible, and exhibited to various persons in the audience. Subsequently it was presented by the lecturer to the President as a *memento* of the occasion.

At the conclusion of the lecture and experiments the unanimous thanks of the Institute were tendered to Professor Bone, in a rising vote.

The meeting then took a recess, to finally adjourn in the morning, while on the excursion.

On board Steamer "Alton."

Friday, October 20, 1911.

11 A. M.

The meeting was called to order by the President, and an opportunity given for any matters that remained unfinished prior to adjournment.

The following resolution was then offered, and unanimously adopted, after which the meeting adjourned, sine die:

DR. HUMPHREYS: Mr. President I desire to offer the following resolution:

Resolved, That the thanks of the Institute are due to Mr. Charles L. Holman, and the other members of the Committee on Arrangements, for their effective labors in preparing for this meeting. As a result of their efforts, the meeting has been one of the most pleasant, as well as profitable, that this Institute has ever held. The unique features of the Institute dinner will long be remembered with keen pleasure. (Applause.)

Upon motion the resolution was unanimously adopted.

Mr. Walton Forstall offered the following resolution, which was unanimously adopted:

Resolved, That the Institute desires to place on record its appreciation of the result of the efforts of those members who were responsible for bringing Professor Bone to St. Louis, and thus afforded this meeting an opportunity of listening to a lecture which was enjoyable in its presentation and which promises to increase vastly the industrial usefulness of gas.

MR. MILLER: Mr. President, I wish to move the following resolution:

Resolved, That the members of the American Gas Institute wish to express their hearty appreciation of, and thanks to the officers, directors and committee members, for the time and care expended in the work of the Institute during the year, and

in the preparation for and conduct of the meeting. The work of the Institute is great in extent and most exacting; and the members appreciate the effort expended, and the excellent results.

This resolution was duly seconded and upon the request of the President, Dr. Humphreys presided during the voting and declared that the resolution had been unanimously adopted. Dr. Humphreys on behalf of the members of the Institute thanked the officers, directors and committee members in accordance with the resolution passed.

(The convention then adjourned.)

In Memoriam.

J. K. BEATTY, Pittsburgh, Pa.
DIED APRIL 9, 1910

H. E. KINCAID, Jackson, Tenn.
DIED NOVEMBER 14, 1910

FREDERICK LINES BRADLEY, New York, N. Y.
DIED DECEMBER 4, 1910

CHAS. HUMPHREY GIFFORD, New Bedford, Mass.
DIED DECEMBER 26, 1910

JOHN D. S. NEELY, Lima, Ohio
ASSASSINATED JANUARY 7, 1911

CARL A. DICKEL, Philadelphia, Pa.
DIED JANUARY 15, 1911

JOHN FOWLER, Philadelphia, Pa.
DIED APRIL 20, 1911.

ARTHUR POSTLEY, New York, N. Y.
DIED MAY 16, 1911

WILLIAM H. ALLEN, Newark, N. J.
DIED MAY 20, 1911

ARTHUR RIBLET, New York, N. Y.
DIED JUNE 15, 1911

JOHN C. DODS, Cherryvale, Kan.
DIED SEPTEMBER 1, 1911

THOMAS LATIMER GEORGE, Philadelphia, Pa.
DIED AUGUST 21, 1911

HON. S. R. DRESSER, Bradford, Pa.
DIED JANUARY 20, 1911

RICHARD HENRY THOMAS, New York, N. Y.
DIED JANUARY 24, 1911

HARRY WOODWARD COLEMAN, Philadelphia, Pa.
DIED JANUARY 30, 1911

JOHN KERR BEATTY.

Mr. Beatty, Consulting Superintendent and until recently General Superintendent of the Philadelphia Company, and one of the most widely known natural gas experts in the United States, died at 11.30 o'clock, April 9, 1910, after an illness of seven months, at his home, 122 Hutchinson Avenue, Edgewood Park, Pittsburg. Mr. Beatty was born November 15, 1849, near Garrett's Run, Armstrong County. After an education in the public schools, and during the early days of the oil excitement, Mr. Beatty was attracted there and he became identified in various capacities with the oil industry, becoming a pioneer in the natural gas business, as superintendent of the Clarendon Gas Company, of Clarendon, Pa., one of the first concerns to sell natural gas for domestic purposes.

In 1885 Mr. Beatty became associated with the Philadelphia Company as District Superintendent in the Murrysville field, being in charge of the extensive operations of the company in that important field. New duties were added to the work of Mr. Beatty until he became General Superintendent in 1897, retaining that position until recently, when continued illness forced him to accept the position of Consulting Superintendent, where he was able to give the company the benefit of his long experience without burdening himself with regular office duties.

H. E. KINCAID.

Mr. Kincaid, Secretary and Manager of the Jackson (Tenn.) Gas Company, died at his home in that city, the night of Sunday, November 14, 1910.

Mr. Kincaid was in his 45th year, and had been in the service of the company for more than twenty years, having been quite active and prominent in the affairs of Jackson.

Mr. Kincaid was a Charter Member of the Institute.

FREDERICK LINES BRADLEY.

Mr. Bradley was born in New Haven, Conn., March 26, 1850, and entered the service of the New York Gas Light Company in 1876 and in 1885 took charge of the 99th Street Station of the Consolidated Gas Company, which position he held at the time of his death, which occurred December 4, 1910.

Mr. Bradley was a Charter Member of the Institute and attended the meetings with great regularity. He united with the American Gas Light Association in 1889. He was a member of the "Society of Gas Lighting," "Society of Colonial Wars" and the "Sons of the Revolution."

CHARLES HUMPHREY GIFFORD.

Mr. Gifford was born in West Gardner, Me., in 1861. At an early age he removed with his family to Little Compton, R. I.

As a young man he learned the carpenter's trade in New Bedford and in 1882 entered the employment of the then New Bedford Gas Light Company. He soon was placed in charge of the outside electric lines of the company, which position he held until 1902, when he took charge of the gas manufacturing department of the company.

On the morning of December 26, 1910, he died suddenly as he was entering the office of the gas works.

For more than 28 years he was a faithful servant of the gas company and its service was the dominating factor in his life.

He joined the American Gas Light Association in 1904 and was a Charter Member of the Institute.

JOHN D. S. NEELY.

Mr. Neely, General Manager of the Lima (Ohio) Gas Light Company, a Charter Member of the Institute, was assassinated January 7, 1911, at Caney, Kansas. Mr. Neely was also President of the Wichita Natural Gas Company and engaged in a lawsuit over a certain lease which was instituted by his

company and it is claimed the deed was committed by a party on the opposite side.

CARL A. DICKEL.

Mr. Dickel, Secretary of the Cyrus Borgner & Company, Fire-Brick Works, Philadelphia, Pa., in which concern he had served in various capacities since boyhood, died January 15, 1911, in his 33d year and was buried in that city. Mr. Dickel was a Charter Member of the Institute, a member of the American Gas Light Association from 1902 until transferred to the Institute.

JOHN FOWLER.

Mr. Fowler, born in Philadelphia in 1816, was one of the old-time Gas Engineers, having been a member of the firm of Deily & Fowler Gas Holder Manufacturing Company. Mr. Fowler died April 20, 1911, and was therefore nearly a century old.

Mr. Fowler united with the American Gas Light Association as an Active Member in 1879 and was a Charter Member of the Institute. He was a regular attendant for many years and a prominent and influential citizen in his community.

ARTHUR POSTLEY.

Mr. Postley, for many years prominent in the engineering service of the Consolidated Gas Company, distribution department, New York City, and prior thereto on the staff of the Manhattan Gas Light Company, died at his home in New York City, May 16, 1911, in his 46th year. He became a member of the Institute in 1908 and was also a member of the Mechanical Engineers.

WILLIAM H. ALLEN.

Mr. Allen, Manager of the Appliance Division of the Public Service Gas Corporation of New Jersey died at his home in Newark, May 20, 1911. Mr. Allen became a member of the

American Gas Light Association, October, 1901, he was a Charter Member of the National Commercial Gas Association and a Charter Member of the Institute. Mr. Allen was very successful in his work and a man very popular with his associates.

ARTHUR RIBLET.

Mr. Riblet died in New York City, June 15, 1911, in his 64th year. Mr. Riblet was for 48 years continuously in the service of the Manhattan and Consolidated Gas Companies and for over 30 years the capable Superintendent of the 14th Street works. Mr. Riblet was of a retiring disposition but well equipped for his important duties. He united with the Institute October, 1910.

JOHN C. DODS.

Mr. Dods was born in 1846 at Spalding, in Lincolnshire, England, and came to this country in 1870 as an engineer for an English firm with headquarters in Boston. Mr. Dods became expert in construction of steel furnaces and was for several years connected with the LaClede Fire-Brick Manufacturing Company of St. Louis and at the time of his death, September 1, 1911, was Superintendent of the Edgar Zim Company, Cherryvale, Kansas.

THOMAS LATIMER GEORGE.

Mr. George was born in Philadelphia, Pa., February 1, 1846, and early in life entered the employ of the "City Gas Trust" of that city as Chief Bookkeeper and Controller, which position he held until the United Gas Improvement Company took over the gas works, when he was made General Agent, a position he held until his death, August 21, 1911. Mr. George was a brother of Henry George, the single tax exponent. He became a member of the American Gas Light Association in 1899 and therefore was a Charter Member of the Institute.

HON. S. R. DRESSER.

Mr. Dresser, President of the S. R. Dresser Manufacturing Company, Bradford, Pa., was born in Litchfield, Michigan, February 1, 1842, and was a graduate of Hillsdale College. He became interested in the oil business, locating at Bradford in 1865 and was the inventor of several important devices for the better handling of oil and natural gas. He was a member of the 58th and 59th Congress. He died January 20, 1911, and by reason of his numerous inventions for gas distribution was well and favorably known to the gas fraternity. He united with the Institute October, 1906, and was therefore a Charter (Associate) Member.

RICHARD HENRY THOMAS.

Mr. Thomas was born in Brantford, Ontario, in 1869. In 1894 he moved to New York and affiliated with the Consolidated Gas Company as their Gas Engineer Expert. He afterwards became Eastern Representative of the White & Middleton Gas Engine Company, which he held for twelve years, in 1904 as President of the Thomas, Roberts, Stevenson Company he united with the American Gas Light Association as an Associate Member and continued a member of the Institute until his death, January 24, 1911. Mr. Thomas was active in social and civil matters and a member of several well known clubs.

HARRY WOODWARD COLEMAN.

Mr. Coleman was born in 1864 at Newport, Ky., and when 22 years old associated in business with Mr. J. K. Dimmick and the Addyston Pipe and Foundry Company, Addyston, Ohio. Later he was associated with the Anniston Pipe and Foundry Company, Anniston, Ala., and in 1908 moved to Philadelphia and engaged in business with the J. K. Dimmick & Company, wholesale dealers in pig iron, cast iron pipe, etc., making a specialty of dealing with gas companies. He became a member of the American Gas Light Association in 1898 and was therefore a Charter Member of the Institute. His death occurred January 30, 1911.